A vegetation description and floristic analyses of the springs on the Kammanassie Mountain, Western Cape

G. CLEAVER, L.R. BROWN and G.J. BREDENKAMP

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The Kammanassie Mountain is a declared mountain catchment area and a Cape mountain zebra *Equus zebra zebra* population is preserved on the mountain. The high number of springs on the mountain not only provides water for the animal species but also contributes to overall ecosystem functioning. Long-term conservation of viable ecosystems requires a broader understanding of the ecological processes involved. It was therefore decided that a classification, description and mapping of the spring vegetation of the Kammanassie Mountain be undertaken. A TWINSPAN classification, refined by Braun-Blanquet procedures, revealed 11 major plant communities that could be related to geological origin. Habitat factors associated with differences in vegetation include topography, soil type and grazing. Descriptions of the plant communities include diagnostic species as well as prominent and less conspicuous species of the tree, shrub and herbaceous layers. The results also indicate a high species richness compared to similar regions and the difference between plant communities of wet and dry springs. This data is important for long-term monitoring of the spring ecosystems as well as for the compilation of management plans.

Keywords: springs, Kammanassie Mountain, Braun-Blanquet, plant communities, TWINSPAN, plant species richness.

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Introduction

The Kammanassie Nature Reserve was established in 1978 to conserve the Cape mountain zebra *Equus zebra zebra* population present in the area and the natural ecosystems as part of the mountain catchment area. The area has a high species richness compared to similar vegetation types (Cleaver *et al.* 2003; Cleaver 2004). A large number of springs is found scattered throughout the reserve contributing to the high species richness and different ecosystem functioning while also providing drinking water to various animals, especially the Cape mountain zebra (Cleaver 2004).

A total of 53 springs have been located on the Kammanassie Mountain. During 1998, it was noticed that certain springs were drying up. This was cause for concern for the survival of Cape mountain zebra on the reserve. Therefore, spring monitoring was initiated on the Kammanassie Mountain during 1999. Flora occurring at flowing springs were thought to be unique and in danger of being lost should further springs dry up on the mountain. It was decided to determine the floristic composition of springs to give an indication of what flora is currently found at the springs and what species could be lost should further flowing springs dry up on the reserve. This information is important for future management purposes.

Furthermore, the Department of Water Affairs and Forestry (DWAF) abstract approximately 0.65 x 106 m^3/a of groundwater from five production boreholes on the

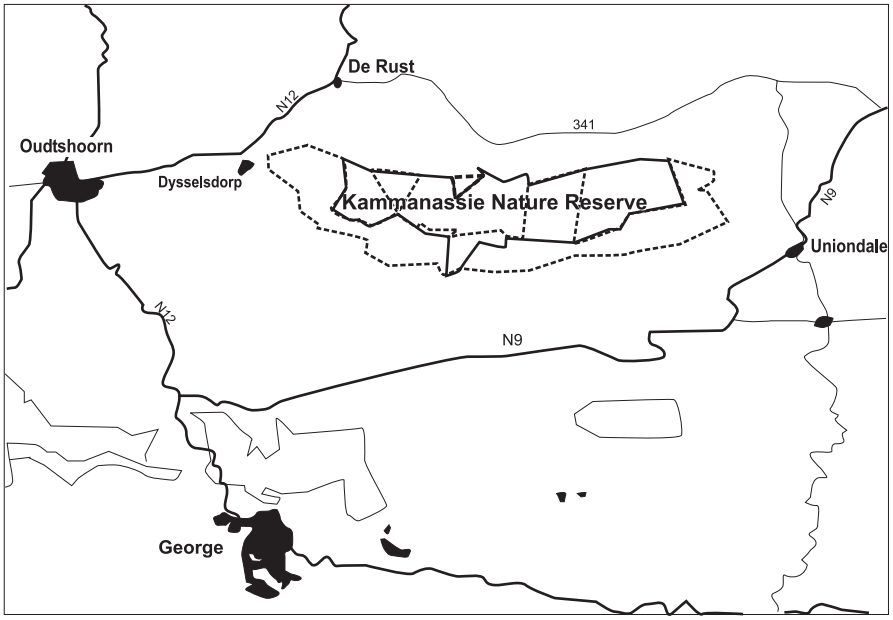

Fig. 1. Location of the study area.

Kammanassie Nature Reserve. The Klein Karoo Rural Water Supply Scheme (KKR-WSS) has been in operation since 1993 and the scheme supplies purified domestic water, at subsidised rates, to the town of Dysselsdorp, to farms in the Olifants River valley, to tributary valleys downstream of the Stompdrift and Kammanassie dams, and to the Gamka River valley downstream of Calitzdorp. The effects of large-scale groundwater abstraction on springs is not clearly understood and this study forms part of a larger research project funded by the Water Research Commission to assess the environmental impacts of large-scale groundwater abstraction from Table Mountain Group aquifers on ecosystems in the Kammanassie Nature Reserve.

In order to understand ecosystems and the management thereof (Bredenkamp 1982; Bezuidenhout 1993; Brown & Bezuidenhout 2000), it is important to classify, describe and map the different vegetation types found in the spring areas of the Kammanassie Mountain (Van Rooyen *et al.* 1981; Brown & Bezuidenhout 2000). This data will also be used in the long-term monitoring of the spring ecosystems as well as for compiling a management plan.

The Study Area

The Kammanassie Mountain complex is situated between the towns of Uniondale in the east and De Rust/Dysselsdorp in the north-west and west (Fig. 1). The mountain is an inselberg within the Little Karoo between the Swartberg and Outeniqua Mountains. The total area of the mountain range, managed by the Western Cape Nature Conservation Board (WCNCB), is 49 430 ha of which 21 532 ha are privately owned and a declared mountain catchment. The remaining 27 898 ha are state land, of which 17 661 ha have been declared State Forest. The Kammanassie Nature Reserve is situated between

33°33'S–33°37'S and 22°27'E–23°01'E and was proclaimed a protected area in 1978 as an important water catchment area (Cleaver 2002).

According to Rebelo (1996) and Lubke (1996) the Kammanassie Mountain falls into the fynbos and thicket biomes with small pockets of the forest biome present in the kloofs on the southern slopes of the Kammanassie Nature Reserve (Cleaver 2002).

The average monthly rainfall and minimum and maximum temperatures for the study area are indicated in Fig. 2. The reserve receives rain throughout the year, with an average annual rainfall of ± 450 mm. The highest annual rainfall of 1216 mm and lowest of 242 mm were recorded in 1981 and 1984 respectively. The hottest months on the Kammanassie Nature Reserve are December to February with maximum temperatures of 35 ºC and the coldest months are June and July with minimum temperatures of -2 ºC (Fig. 2).

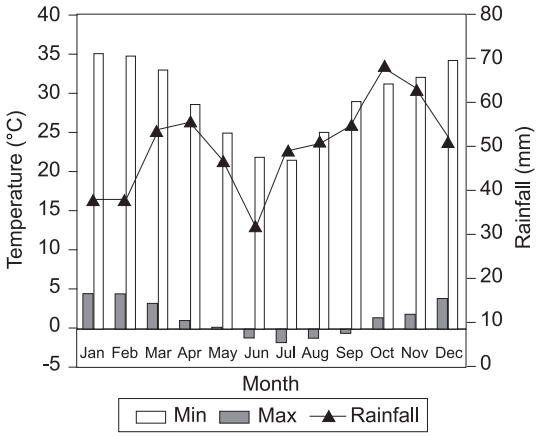

Fig. 2. The average monthly rainfall and the mean average minimum and maximum temperatures of the Kammanassie Nature Reserve.

The Kammanassie is one of the prominent East-West trending ranges comprising the southern branch of the Cape Fold Belt. It was formed as a result of North-South oriented compressive stress during the Cape Orogeny 123-200 million years ago (Hälbich & Greef 1995). The Kammanassie Nature Reserve is an eroded remnant of the Kammanassie mega-anticline (Hälbich & Greef 1995). The Kammanassie Mountain Range comprises almost exclusively the resistant quartz arenites of the Table Mountain Group, overlain on the lower slopes by the shale of the Bokkeveld Group (Kotze 2001). A very important shale marker horizon, the Cedarberg Formation (50–120 m thick) occurs within the Table Mountain Group, separating formations of the Peninsula Formation from the lithologies comprising the Nardouw Formation (Kotze 2001).

According to Kotze (2001), the Peninsula Formation is a highly competent succession of medium to coarse-grained, thickly bedded, grey sandstone. The Nardouw Formation weathers more brownish, and thin shale intercalations are more common, than in the Peninsula Formation. As a result the Nardouw Formation is more ductile (Kotze 2001).

Soil generally forms a thin (<1 m) veneer of silty sands as a result of the steep slopes of the Kammanassie Mountain and predominantly quartzitic rocks. Locally, clayey soil occurs in association with weathered shale horizons and, in particular, the Cedarberg Formation (Cleaver *et al.* 2003).

Methods

Relevés were compiled at 52 of the known springs on the Kammanassie Mountain. Spring localities were identified by Kammanassie Nature Reserve Staff, who monitor these springs (flow rates and water samples) annually during February/March. The coordinates of each spring were determined using an Omnistar Global Positioning System (GPS). To facilitate this monitoring, each individual spring was given a number, beginning at 01. The prefix Kamm is the standard WCNCB monitoring code used for the Kammanassie Nature Reserve while the standard

WCNCB code for water monitoring is indicated by the letter 'w' (Van der Walt 1993).

Floristic composition of springs (woody species, grasses and forbs) was surveyed at the origin of the spring using the Braun-Blanquet cover-abundance scale (Mueller-Dombois & Ellenberg 1974). The area sampled varied from spring to spring and was determined to include at least 95% of all floral species present at the site. Care was taken to sample only homogeneous spring vegetation and not to include adjacent drier communities. Fieldwork was carried out between February and April 2002. Environmental data recorded included aspect, altitude, slope, geology, soil texture, percentage rock cover and rock size (small, small/medium, medium, medium/large and large).

A first approximation of the main plant communities was derived by applying the two-way indicator species analysis (TWINSPAN) (Hill 1979) to the floristic data set. Further refinement of the classification was achieved by Braun-Blanquet procedures (Bredenkamp *et al.* 1989; Kooij *et al.* 1990; Bezuidenhout 1993; Eckhart 1993; Brown & Bredenkamp 1994). The results are presented in a phytosociological table produced by using MEGATAB (Hennekens 1996a). Springs showing similar plant communities were plotted on an ArcView (Ver. 3.2) Geographical Information System (GIS) generated map, to indicate their localities.

Plant taxon names conform to those given by Goldblatt and Manning (2000). These names may therefore differ from the plant species list used by the TURBOVEG database (Hennekens 1996b), which is based on the PRECIS database of the National Botanical Institute (NBI) in Pretoria, as on date 1997. Red data status follows Hilton-Taylor (1996).

Results

Classification

The results are presented in a phytosociological table (Table 1). The analysis resulted in the identification of the following fourteen plant communities, which can be grouped into 11 major community types:

1. *Blechnum tabulare-Hippa frutescens* fern community
1.1. *Hippia frutescens-Helichrysum cymosum* shrubland
1.2. *Hippia frutescens-Helichrysum petiolare* shrubland
1.3. *Hippia frutescens-Ehrharta* species grassland
2. *Eragrostis plana-Juncus lomatophyllus* grassland
3. *Berzelia intermedia-Psoralea verrucosa* shrubland
4. *Cliffortia ilicifolia-Stoebe plumosa* shrubland
5. *Ehrharta ramosa-Aspalathus kougaensis* shrubland
6. *Conyza canadensis-Conyza scabrida* shrubland
7. *Phragmites australis* reed community
8. *Ehrharta erecta-Rhus pallens* shrubland
9. *Mentha longifolia-Thelypteris confluens* shrubland
10. *Pelargonium radulifolium-Salvia namaensis* shrubland
11. *Ehrharta erecta-Crassula biplanata* shrubland

Description of spring plant communities

In the descriptions of the different spring plant communities, all species groups refer to Table 1. The position of the springs (spring numbers) with similar plant communities is indicated in with same colour and symbol in Fig. 3.

1. *Blechnum tabulare-Hippa frutescens* fern community

The springs with vegetation belonging to this community are mainly found on southern slopes on the Kammanassie Mountain.

Altitude varies between 837-1394 m above sea level. The soil is loamy to clayey with rock cover varying between 5-40%. All the springs of this community are perennial and undisturbed.

Diagnostic species include the dwarf shrub *Hippa frutescens* and the ferns *Blechnum tabulare* and *Blechnum inflexum* (species group A).

This community can be sub-divided into the following three sub-communities:

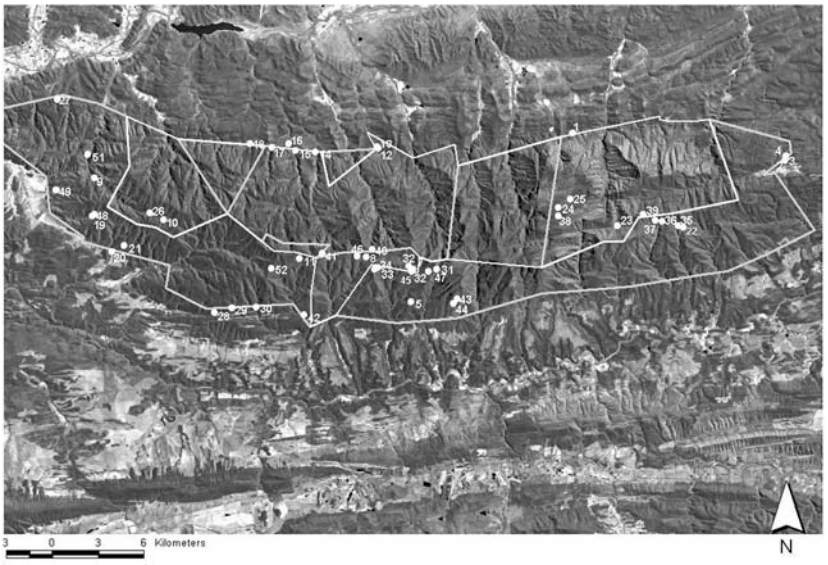

Fig. 3: Location of the vegetation communities of springs on the Kammanassie Nature Reserve.

1.1 *Hippia frutescens-Helichrysum cymosum* shrubland

The vegetation of springs Kamm/w/22 and 37 (Mannetjiesberg), Kamm/w/31 (Elandsvlakte) and Kamm/w/52 (Wildealsvlei) fall within this sub-community.

Altitude varies between 1038-1361 m a.s.l. All springs occur on gentle slopes (1-2°) with a south-southwestern aspect. Rock cover varies between 5 % to 40 %. All four springs were flowing but the spring Kamm/w/22 had water though not flowing at the time of the survey.

The shrub layer comprises 50-60 % and the herbaceous layer 30-40 %.

Diagnostic species include the shrub *Helichrysum cymosum*, the moss *Racomitrium lamprocarpum* and the restio *Calopsis paniculata* (species group B). The dwarf shrub *Hippia frutescens* (species group A) is dominant while the ferns *Blechnum tabulare* and *Blechnum inflexum* (species group A) are locally dominant in this sub-community. The shrubs *Helichrysum petiolare* (species group C), *Psoralea verrucosa* and small fern *Hymenophyllum tunbridgense* (species group F) are prominent. Other prominent species include the cosmopolitan weed *Spergularia rubra* and the moss *Jamesoniella* species.

1.2 *Hippia frutescens-Helichrysum petiolare* shrubland

The *Hippia frutescens-Helichrysum petiolare* sub-community is found at springs Kamm/w/35 and Kamm/w/36 (Mannetjiesberg) which were both flowing during the period of the survey.

These springs occur on gentle slopes (1-2°) between 1343-1394 m a.s.l. where the aspect is south-southwest. Soil texture is sandy-loamy and with small-to-medium rocks, with a coverage of 30-40 % of the soil surface.

Shrub cover is 70 % and herbaceous cover is 30 %.

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Table 1

Phytociological table of the vegetation of springs on the Kammanassie Mountain

Community number	1			2	3	4	5	6	7	8	9	10	11
	1.1	1.2	1.3										
Relevè numbers	2235	33	134	35	44	2334	233223	222	14	24	1114	4	1111
	1950	34	4014	2321	5126	2083	7467	389	067	990	57	3568	1897
													1247
													86
Species Group A (Diagnostic species of *Blechnum tabulare-Hippia frutescens* fern community)													
Hippia frutescens	b1a+	.b	.+++	....	 1	+.....	...	...	..	....	....	....	..
Blechnum tabulare	.a+.	.+	+r..	....	.....	.....	...	...	..	....	....	....	..
Blechnum inflexum	..1+	..	.+..	....	...a..	r.....	...	...	..	....	....	....	..
Species Group B (Diagnostic species of *Hippia frutescens-Helichrysum cymosum* shrubland)													
Helichrysum cymosum	+++r	..	.. 11	....	.r....++.	+.1...+	.+.	.r+	..	....	....	....	..
Racomitrium lamprocarpum	.aa.	..	....	....	.....	.....	...	...	..	....	....	....	..
Campylopus species	.3..												
Calopsis paniculata	a+..	..	....	....	.....	.....+	...	...	..	....	....	....	..
Species Group C (Diagnostic species of *Hippia frutescens-Helichrysum petiolare* shrubland)													
Helichrysum petiolare	..1.	33	....	....	.....	.....	...	...	..	....	....	....	..
Cliffortia burchellii	....	++	....	....	....1....	.....	...	...	..	....	....	....	..
Species Group D (Diagnostic species of *Hippia frutescens-Ehrharta* species grassland)													
Ehrharta spp.	....	..	.a3a	+...	.....	.....	...	...	..	....	....	....	..
Pelargonium cordifolium	....	..	+++.	....	.....	+.....	...	...	..	....	....	....	..
panicum	....	..	bb..	....	..1...	.....	...	.a.	..	....	....	....	..
Isolepis verrucosula	....	..	ar..	.r..	.....	.....	...	...	..	....	....	....	..
Rhus tomentosa	....	..	+r..	....	.....	.....	.a.	...	..	....	....	....	..
Juncus capensis	...+	..	.+.r	....	.+.....	.....	...	...	..	..+.	....	....	..

Table 1
(continued)

Species Group E (Diagnostic species of *Eragrostis plana-Juncus lomatophyllus* grassland)													
Juncus lomatophyllus	. . . .	. +	+ . . .	a a . 3	. . . a 1 . . + .	. . . .	. . .	. . .	. .	. . . .	. . .	. . . .	. .
Eragrostis plana	. . . .	. .	. r . .	. r 1 +	+ . + + ... +	. . . . 1 a b	. . +	. . .	. .	. . . .	. . .	. . . .	. .
Pelargonium grossularioides	. . . .	. .	. . r .	r + r .	. . . .	. . . .	. . .	r . .	. .	. . . .	. . .	. . . .	. .
Panicum ecklonii	. . . .	. .	+ . + .	. . + 1	. . 1 . . . + . .	. . 1	. . .	. . .	. .	. . . .	. . .	. . . .	. .
Vellereophyton vellereum	. . . .	. .	. . . .	. 1 . r	. . . .	. . . .	. . .	. . .	. .	. . . .	. . .	. . + .	. .
Pennisetum macrourum	. . . .	. .	. . + .	. + + .	. . . .	. . . .	. . .	. . .	. .	. . . .	. . .	. . . .	. a
Gunnera perpensa	+ . . .	. .	. . . .	r 1 . .	. . . .	. . . .	. . .	. . .	. .	. . . .	. . .	. . . .	. .
Species Group F (Diagnostic species of *Berzelia intermedia-Psoralea verrucosa* shrubland)													
Psoralea verrucosa	. . + r	+ +	. r . .	. . . +	1 a 1 + + + + + +	r	. . .	. . .	. .	. . . .	. . .	. . . .	. .
Berzelia intermedia	. . . .	. .	. . . .	. . . .	+ . . + r + 1 + +	r	. . .	. . .	. .	. . . .	. . .	. . . .	. r
Erica curviflora	. . . .	. .	. . . .	. . . .	. 1 1 r + a 1 . .	. . . b . . .	. . .	. . .	. .	. . . .	. . .	. . . .	. .
Watsonia fourcadei	. . . .	. .	a . . +	. . . .	a . b a . + . + .	. . . .	. . .	. . .	. .	. . . .	. . .	. . . .	. .
Platycaulos callistachyus	. . . .	. .	. . . .	. . . .	. + . . . + + + +	. . . .	. . .	. . .	. .	. . . .	. . .	. . . .	. .
Elegia filacea	. . . .	. .	. . . .	. . . .	. 1 . r r . . r .	. . . . . r .	. . .	. . .	. .	. . . .	. . .	. . . .	. .
Selago glomerata	. . . .	. .	. r . .	. . . .	. 1 + ... 1 .	. . . . . 1 .	. . .	. . .	. .	. . . .	. . .	. . . .	. .
Helichrysum anomalum	. . . .	. .	. . . .	. . . .	+ . . + . . . + .	. . . .	. . .	. . .	. .	. . . .	. . .	. . . .	. .
Centella eriantha	. . . .	. .	. . . .	. . . .	. 1 . r a	. . . .	. . .	. . .	. .	. . . .	. . .	. . . .	. .
Ischyrolepis ocreata	. . . .	. .	. . . .	. . . .	. . . . . + + . +	. . . .	. . .	. . .	. .	. . . .	. . .	. . . .	. .
Clutia alaternoides	. . . .	. .	. . . .	. . . .	+ . . + . . + . +	. . . .	. . .	. . .	. .	. . . .	. . .	. . . .	. .
Species 788	. . . .	. .	. . . .	. . . .	. . r . . + . r .	. . . .	. . .	. . .	. .	. . . .	. . .	. . . .	. .
Helichrysum zeyheri	. . . .	. .	. . . .	. . . .	1 . . . . . a . .	. + + ...	. . .	. . .	. .	. . . .	. . .	. . . .	. .
Juncus dregeanus	. . . .	. .	. . . .	. . . .	. 1 1	. . . .	. . .	. . .	. .	. . . .	. . .	. . . .	. .
Melasma scabrum	. . . .	. .	. . . .	. . . .	. 1 + ...	. . . .	. . 1	. . .	. .	. . . .	. . .	. . . .	. .
Hymenophyllum tunbridgense	. 1 . .	. .	. . . .	. . . .	. + . + ...	. . . .	. . .	. . .	. .	. . . .	. . .	. . . .	. .
Symphyogyna podophylla	. . . .	. .	. . . .	. . . .	. . . 3	. . . .	. . .	. . .	. .	. . . .	. . .	. . . .	. .
Riccardia species	. . . .	. .	. . . .	. . . .	. . . . . 3 . . .	. . . .	. . .	. . .	. .	. . . .	. . .	. . . .	. .
Campylopus species	. . . .	. .	. . . .	. . . .	. . . 3 . 3 . . .	. . . .	. . .	. . .	. .	. . . .	. . .	. . . .	. .
Sematophyllum species	. . . .	. .	. . . .	. . . .	. . . 3	. . . .	. . .	. . .	. .	. . . .	. . .	. . . .	. .
Plecostachys polifolia	. . . .	. .	. . . .	. . . +	. . . . 1 + . . .	. . . 1 . . .	. . .	. . .	. .	. . . .	. . .	. . . .	. .

Table 1
(continued)

Species Group G (Diagnostic species of *Cliffortia ilicifolia-Stoebe plumosa* shrubland)	
Stoebe plumosa	|. . . . . |. . |. . . . . |. . . . . |r . 1 . . . . |. 1 1 a + . + |. . . |. . a |. . |. . . . . |. . . |. . . . . |. . |
Cliffortia ilicifolia	|. . . . . |. . |. . . . . |. . . . . |. . . . + . + . . |r . . r . + b |. . 1 |. . . |. . |. . . . . |. . . |. . . . . |. . |
Pentaschistis sp (831)	|. . . . . |. . |. . . . . |. . . . . |. . . . . |. 3 . . . a . |3 . . |. . . |. . |. . . . . |. . . |. . . b |. . |
Species Group H (Diagnostic species of *Ehrharta ramosa-Aspalathus kougaensis* shrubland)	
Aspalathus kougaensis	|. . . . . |. . |. . . . . |. . . . . |. . . . . |. . . . . r 1 . |. 1 1 |r . . |. . |. . . . . |. . . |. . . . . |. . |
Ehrharta ramosa	|. . . . . |+ . |. . . . . |. . . . . |r 1 . . . . . . 1 |. . . . . |1 . b |. . . |. + |. . . . . |. + . |. . . 1 |. . |
Phylica paniculata	|. . . . . |. . |. . . . . |. . . . . |. . . . . |. . . . . |1 . + |. . . |. . |. . . . . |. . . |. . . . . |. r |
Ficinia ramosissima	|. . . . . |. . |. . . . . |. . . . . |. . . . . r |. . . . . |+ 3 . |. . + |. . |. . . . . |. . . |. . . . . |. .
Dodonaea angustifolia	|. . . . . |. . |. . . . . |. . . . . |. . . . . |. . . . . |a . . |. . . |. . |. . . . . |. . . |. . . . . |. .
Anomalanthus anguliger	|. . . . . |. . |. . . . . |. . . . . |. . . . . |. . . . . |. . 1 |. . . |. . |. . . . . |. . . |. . . . . |. .
Panicum repens	|. . . . . |. . |. . . . . |. . . . . |. . . . . |. . . . . |a . |. + . |. . |. . . . . |. . . |. . . . . |. .
Pentameris species	|. . . . . |. . |. . . . . |. . . . . |. . . . . |. . . . . |. . a |. . . |. . |. . . . . |. . . |. . . . . |. .
Tetraria capillacea	|. . . . . |. . |. . . . . |. . . . . |. . . . . |. . . . . |. . a |. . . |. . |. . . . . |. . . |. . . . . |. .
Juncus oxycarpus	|. . . . . |. . |. . . . . |. . . . . |. . . . . |. . . . . |1 . . |. . . |. . |. . . . . |. . . |. . . . . |. .
Pteronia stricta	|. . . . . |. . |. . . . . |. . r . |. . . . . |. . . . . 1 . |. 1 . |. . . |. . |. . . . . |. . . |. . . . . |. .
Ursinia anthemoides	|. . . . . |. . |. . . . . |. . . . . |. . . . . |. . . . . |. . 1 |. . . |. . |. . . . . |. . . |. . . . . |. .
Senecio ilicifolius	|. . . . . |. . |. . . . . |. . . . . |. . . . . . . r . . |. . . . . |. . 1 |. . . |. . |. . . . . |. . . |. . . . . |. . |
Species Group I (Diagnostic species of *Conyza canadensis-Conyza scabrida* shrubland)	
Conyza scabrida	|. . . . . |. . |. . . . . |+ . . r |. . . . . |. . . . . |. . . |a 3 3 |. . |. . . . |. b b |. . . . . |. . |
Conyza canadensis	|. . . . . |. . |. . . . . |. . . . . |. . . . . |. . . . . |. . . |. 1 r |. . |. . . . |. r . |. . . . . |. . |
Helichrysum nudifolium	|. . . . . |. . |. . . . . |. . . . . |. . . . . |. . . . . |. . . |+ . 1 |. . |. . . . |. r r |. . . . . |. . |
Anthospermum aethiopicum	|. . . . . |. . |. . . . . |. . r . |. + ... + . . |. . . . . . . r |. . 1 |r . + |. . |. . . . |. . . |. . . . . |. . |
Species Group J (Diagnostic species of *Phragmites australis* reed community)	
Phragmites australis	|. . . . . |. . |. . . . . |. 3 . . |. . . . . |. . . . . |. . . |. . . |5 3 |. . . . |. . . |. . . . . |. . |

Table 1
(continued)

Species Group K (Diagnostic species of *Ehrharta erecta-Rhus pallens* shrubland)													
Rhus pallens	. . . .	. .	. . . .	. . . .	. . . .	. . . .	. . .	. . 1	. a	. a + a	r r .	r . a .	. +
Ehrharta erecta	. . + .	. .	. . . .	. 1 . .	. . . .	. . . .	. . 1	. . .	. .	. b 3 .	. . +	. . . .	b .
Pollichia campestris	. . . .	. .	. . . .	. . . .	. . . .	. . . .	. . .	. . .	. .	r . + .	. . .	. . + .	. .
Tarchonanthus camphoratus	. r . .	. .	r . . .	. . . .	. . . .	. . . .	. . .	. . .	. .	. . 3 +	r . .	. . . .	. .
Salix mucronata	. . . .	. .	. . . .	. . . .	. . . .	. . . .	. . .	. . .	. .	1 3 . .	. . r	. . . .	. .
Sutera campanulata	. . . .	. .	. . . .	. . . .	. . . .	. . . .	. . .	. . .	. .	. + . +	. . .	. . . .	. .
Species Group L (Diagnostic species *Mentha longifolia-Thelypteris confluens* shrubland)													
Thelypteris confluens	. . . .	. .	. . . .	. . . .	. . . .	. . . .	. . .	. . .	. .	. . . .	+ + a	. . . .	. .
Mentha longifolia	+ . . .	. .	. . . .	+ . . .	. . . .	. . . .	. . .	. . .	. .	. . 1 .	. a a	. . . .	. .
Calpurnia intrusa	. . . .	. .	. . . .	. . . .	. . . .	. . . .	. . .	. . .	. .	. . . .	. + +	. . . .	. .
Pelargonium zonale	. . . .	. .	. . . .	. . . .	. . . .	. . . .	. . .	. . .	. r	. . . .	. + +	. . . .	. .
Stachys aethiopica	. . . .	. .	. . . .	. . . .	. . . .	. . . .	. . .	. . +	. .	. . . .	r + .	. . . .	. .
Species Group M (Diagnostic species of *Pelargonium radulifolium-Salvia namaensis* shrubland)													
Salvia namaensis	. . . .	. .	. . . .	. . . .	. . . .	. . . .	. . .	. . .	. .	. . . .	. . .	b b + a	. .
Pelargonium radulifolium	. . . .	. .	. . . .	. . . .	. . . .	. . . .	. . .	. . +	. .	. . 1 .	. . .	. + . a	. .
Dipogon lignosus	. . . .	. .	. . . .	. . . .	. . . .	. . . .	. . .	. . .	. .	. . . .	. . .	. . r 1	. .
Cissampelos capensis	. . . .	. .	. . . .	. . . .	. . . .	. . . .	. . .	. . .	. .	. . . .	. . .	. . + 1	. .
Mariscus congestus	. . . .	. .	. . . .	. 1 . .	. . . .	. . . .	. . .	. . r	. .	. . . .	. . .	r r . .	. .
Species Group N (Diagnostic species of *Ehrharta erecta-Crassula biplanata* shrubland)													
Crassula biplanata	. . . .	. .	r . . .	. . . .	. . . .	. . . .	. . .	. . .	. .	. . . .	. . .	. . . .	+ r
Species 814 (forb)	. . . .	. .	. . . .	. . . .	. . . .	. . . .	. . .	. . .	. .	. . . .	. . .	. . . .	+ 1

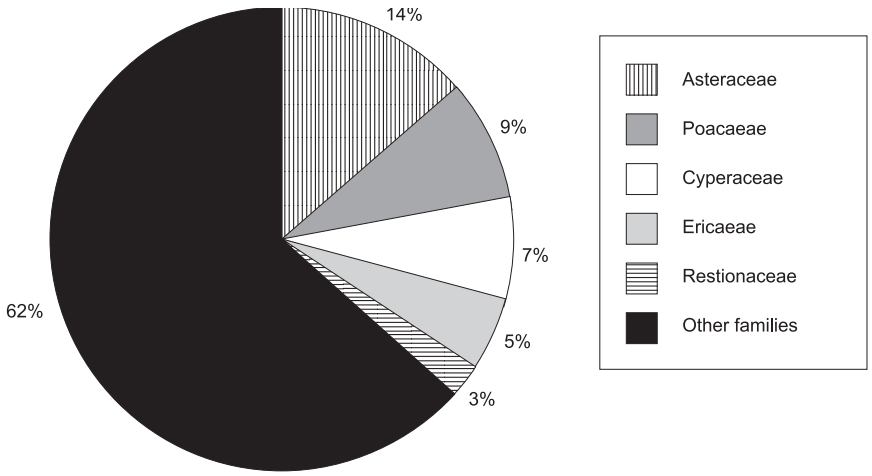

Fig. 4. Dominant plant families reflecting the percentage of total flora of springs on the Kammanassie Mountain.

Diagnostic species include the shrubs *Helichrysum petiolare* and *Cliffortia burchelli* (species group C). The shrub *Hippia frutescens* and the fern *Blechnum tabulare* (species group A) are prominantly present. The shrub *Psoralea verrucosa* (species group F) is also conspicuous in this subcommunity.

1.3 *Hippia frutescens-Ehrharta* species grassland

This sub-community is found at the following springs: Kamm/w/05 (Buffelsdrif), Kamm/w/11 (Wildebeesvlakte), Kamm/w/33 (Elandsvlakte) and Kamm/w/46 (Upper Diepkloof). The spring Kamm/w/05 dried up in December 2001 and Kamm/w/33 dried up in 2000. At the time of the survey Kamm/w/11 had water but was not flowing and Kamm/w/46 was flowing.

Altitude varies between 837-1154 m a.s.l. on a gentle slope. All these springs occur on south-facing slopes. Soil is sandy, while rock cover is very low, at most localities less than 5 %.

Shrubs cover an estimated 60 % of the area and the herbaceous layer 40 %.

Diagnostic species include the shrubs *Pelargonium cordifolium* and *Rhus tomentosa*, the grass *Ehrharta* species , the restios *Isolepsis verrucosula* and *Juncus capensis* and aquatic plant *Eleocharis limosa* (species group D). The shrub *Hippia frutescens*, ferns *Blechnum tabulare* and *Blechnum inflexum* (species group A) are also prominent. Other prominent local species include the shrub *Helichrysum cymosum* (species group B), restio *Juncus lomatophyllus* and grasses *Panicum ecklonii* and *Pennisetum macrourum* (species group E) and *Watsonia fourcadei* (species group F). (Fig. 4)

2. *Eragrostis plana-Juncus lomatophyllus* grassland

The vegetation of springs Kamm/w/02 and 03 (Kleinfonteinsberg), Kamm/w/34 (Elandsvlakte) and Kamm/w/53 (Mannetjiesberg) represent this plant community. Some springs dried up, e.g., Kamm/w/02 in 1978, Kamm/w/03 in 1999, Kamm/w/34 in 2000, but Kamm/w/53 was flowing at the time of the survey.

Altitude varies considerably between 867-1405 m above sea level, while slope also varies considerably between 1-11°. The

aspect is northeast to north-northeast. Rock cover is low and is less than 5 % in most cases while the soil texture is loamy-clay.

Shrub cover is between 10-40 % and the herbaceous layer between 40-60 %.

Diagnostic species include grasses such as *Eragrostis plana*, *Panicum ecklonii*, *Pennisetum macrourum*, restio *Juncus lomatophyllus*, shrub *Gunnera perpensa* and the forbs *Pelargonium grossularioides* and *Vellereophyton vellereum* (species group E). Other prominent species that occur locally include grasses *Ehrharta* species (species group D) and *Ehrharta erecta* (species group K), the tall reed *Phragmites australis* (species group J), and sedge *Mariscus congestus* (species group M).

3. *Berzelia intermedia-Psoralea verrucosa* shrubland

A total of nine springs, namely; Kamm/w/06 (Buffelsdrif), Kamm/w/07, 32 and 45 (Elandsvlakte), Kamm/w/23 (Mannetjiesberg), Kamm/w/40 (Kleinberg), Kamm/w/43 and 44 (Groenplaat) and Kamm/w/47 (Kleinrivier) form the habitat of the *Berzelia intermedia-Psoralea verrucosa* shrubland. The spring Kamm/w/06 dried up at the end of 2001, Kamm/w/40 and 43 dried up in 2000 and Kamm/w/47 is dry but the year its spring dried up is unknown. The springs Kamm/w/07, 32, 45 and 23 were all flowing at the time of this survey.

Altitude ranges between 927–1404 m a.s.l. These springs occur on a slope between 1–17° and aspect varies greatly. Rock size is small to medium while rock cover varies between 5–40 %. All these springs are situated on the southern slopes of the Kammanassie Mountain.

Shrubs and herbs have a canopy cover of 50 %.

The diagnostic species from group F include: the shrubs *Psoralea verrucosa*, *Berzelia intermedia*, *Erica curviflora*, *Helichrysum anomalum*, *Clutia alaternoides*, *Helichrysum zeyheri* and *Plecostachys polifolia*, the corm *Watsonia fourcadei*, the restios *Platycaulos callistachyus*, *Elegia filacea*, *Ischyrolepis ocreata* and *Juncus dregeanus*, the forbs *Selago glomerata*, *Centella eriantha*, *Melasma scabrum*, and the small fern *Hymenophyllum tunbridgense*.

Other locally dominant species are the shrubs *Ficinia nigrescens* (species group H) and *Helichrysum cymosum* (species group B), the grasses, *Eragrostis plana* and *Panicum ecklonii* (species group E) and *Ehrharta ramosa* (species group H) and the restio *Juncus lomatophyllus* (species group E). Further conspicuous species locally present include the shrubs *Stoebe plumosa* and *Cliffortia ilicifolia* (species group G) and *Anthospermum aethiopicum* (species group I). The mosses *Symphyogyna podophylla*, *Riccardia* species, *Sematophyllum* species and *Campylopus* species, are prominent locally.

4. *Cliffortia ilicifolia-Stoebe plumosa* shrubland

The vegetation of springs Kamm/w/08 (Elandsvlakte), Kamm/w/24, 25 and 38 (Paardevlakte), Kamm/w/39 (Mannetjiesberg), Kamm/w/30 (Bergplaas) and Kamm/w/41 (Upper Diepkloof) represents a *Cliffortia ilicifolia-Stoebe plumosa* shrubland. All these springs were dry during the survey period. Most of these springs, excluding Kamm/w/08 (2000) and Kamm/w/30 (2001)), dried up before 1993.

Springs belonging to this shrubland are relatively flat with a slight gradient that varies between 1–2°. Altitude varies between 758 m–1475 m a.s.l., and aspect varies greatly. Soil texture is sandy-loam, while the rock cover varies between 40–50 % with little to no rocks present in certain localities.

The shrub and herbaceous layer has a cover of 50 %.

Diagnostic species include the shrubs *Stoebe plumosa*, *Cliffortia ilicifolia* and the grass *Pentaschistis* species 831, which grows in large tufts (species group G). Other locally dominant species include the shrubs

Helichrysum cymosum (species group B), *Helichrysum zeyheri* (species group F), *Aspalathus kougaensis* (species group H) and the grass *Eragrostis plana* (species group E). The large shrub *Chrysanthemoides monilifera*, tree *Protea neriifolia* and succulent *Crassula ericoides* (not included in table 1) also occur locally.

5. *Ehrharta ramosa-Aspalathus kougaensis* shrubland

This plant community occurs at the following three springs: Kamm/w/21 (Leeuwblad) and Kamm/w/28 and 29 (Bergplaas). All these springs dried up between 1999 and 2000.

This community is found at lower-lying areas with altitudes varying between 612 m–797 m a.s.l. on south or west facing aspects. The soil texture is very coarse gravel. Medium-to-large rocks with coverage of between 70–80 % are common.

Shrub and herbaceous coverage is between 30–40%.

Species group H is diagnostic for this community and includes the shrubs *Aspalathus kougaensis*, *Phylica paniculata*, *Ficinia ramosissima* and the grass *Ehrharta ramosa*. *Eragrostis plana* (species group E) is also present. Another locally prominent species is the grass *Pentaschistis* species (species group G). The following species are locally present: the shrubs *Dodonaea angustifolia*, *Pteronia stricta*, *Anomalanthus anguliger*, the grasses *Panicum repens*, *Pentameris* species, the restios *Tetraria capillacea*, *Juncus oxycarpus* and forbs *Ursinia anthemoides* and *Senecio ilicifolius*.

6. *Conyza canadensis-Conyza scabrida* shrubland

The vegetation of springs Kamm/w/10 (Wildebeesvlakte), Kamm/w/20 (Leeuwblad) and Kamm/w/42 (Ylandsrivier) represents the *Conyza canadensis-Conyza scabrida* shrubland.

This plant community occurs at a lower altitude (586–927 m a.s.l.), with slopes of 1-3°. The soil texture varies from sandy, loamy to clay, while rock cover varies between 0–50 %.

The shrub cover varies between 30–50 % and the herbaceous layer coverage is between 30–40 %.

Species diagnostic for this community include the invader *Conyza scabrida*, the shrubs *Conyza canadensis*, *Helichrysum nudifolium* and *Anthospermum aethiopicum* (species group I). The shrubs *Stoebe plumosa* (species group G) and *Rhus pallens* (species group K) are locally prominent within this community.

7. *Phragmites australis* reed community

The dominant vegetation of two springs Kamm/w/26 (Wildebeesvlakte) and Kamm/w/49 (Rietfontein) is *Phragmites australis*. At present these springs are both dry. Kamm/w/26 dried up in 1999 and Kamm/w/49 in 2001.

Altitude varies between 624–862 m a.s.l. Both have a western aspect and occur on gentle slopes of between 1-3°. Soil varies from clay to gravel and rock cover varies from 60 % to no rocks present in certain localities.

The herbaceous layer is dominated by the reed *Phragmites australis* and has a cover of 70 %. Shrub coverage varies (10–30 %).

This community has the reed *Phragmites australis* as the diagnostic and dominant species (species group J). The tree *Rhus pallens* (species group K) is locally prominent within the community.

8. *Ehrharta erecta-Rhus pallens* shrubland

The four springs, Kamm/w/14 (Slawedam I) and Kamm/w/16 (Slawedam II) and Kamm/w/17 (Rooielskloof) and Kamm/w/50 (Rietfontein), are the habitat of the *Ehrharta erecta-Rhus pallens* shrubland. Some springs dried up, viz., Kamm/w/14 in

1994, Kamm/w/17 in 1999, and Kamm/w/16 date unknown. Spring Kamm/w/50 had water but was not flowing during the period of the survey.

Altitude is between 553 -602 m a.s.l. Aspect varies between north to north-east and west. Soil texture is coarse gravel, with medium-to-large rocks present with a coverage of between 60–80 %.

This shrubland has a tree coverage of 10–50 %, a shrub coverage of 30–50 % and herbaceous coverage of 10–20 %.

Species from species group K are diagnostic for this community and include the trees *Tarchonanthus camphoratus* and *Salix mucronata*, the large shrub *Rhus pallens*, the small shrub *Sutera campanulata*, the grass *Ehrharta erecta*, and forb *Pollichia campestris*. The aromatic forb *Mentha longifolia* (species group L) is prominently present.

9. *Mentha longifolia-Thelypteris confluens* shrubland

The vegetation of springs Kamm/w/01 (Buffelsklip), Kamm/w/09 and 51 (Vermaaks River) represent this plant community. The spring Kamm/w/01 was standing at the time of the survey, Kamm/w/09 dried up in 1999 and Kamm/w/51 dried up at the end of 2001.

Altitude is between 569–711m a.s.l. and aspect varies between west, south and north-northwest on a gentle slope. Soil texture is loamy-sandy with rock cover between 30–60 % and less than 5 % in certain areas.

The shrub and herbaceous layer have a 50 % coverage.

The tree *Calpurnia intrusa*, the shrubs *Pelargonium zonale* and *Stachys aethiopica*, the forb *Mentha longifolia* and fern *Thelypteris confluens* (species group L) are diagnostic species of this community. The shrub *Conyza scabrida* (species group I) and grasses *Ehrharta ramosa* and *Ehrharta erecta* (species group H and K) are locally dominant.

10. *Pelargonium radulifolium-Salvia namaensis* shrubland

This plant community occurs at the following springs: Kamm/w/12 and 13 (Kleingeluk), Kamm/w/15 (Slawedam II) and Kamm/w/18 (Solomanskraal). All the springs dried up before 1996. They are found on the northern slopes of the Kammanassie Mountain.

These springs occur at altitudes between 533–684 m above sea level on gentle north to north-east slopes (2°). Soil texture is predominantly sandy to coarse gravel, with rock cover between 20–50 % (medium-to-large).

Shrub coverage varies between 50–70 % and the herbaceous laver has a cover between 10–30 %.

Diagnostic species include the shrub *Salvia namaensis*, the forb *Pelargonium radulifolium*, the creepers *Dipogon lignosus* and *Cissampelos capensis* and the sedge *Mariscus congestus* (species group M). The grass *Ehrharta ramosa* (species group H) and tree *Rhus pallens* (species group K) occur locally while the sedge *Mariscus thunbergii* is locally conspicuous.

11. *Ehrharta erecta-Crassula biplanata* shrubland

The vegetation of the springs (Kamm/w/19 and 48) at Wagenpadnek represent this plant community. Kamm/w/19 dried up in 1999, while Kamm/w/48 was standing at the time of the survey.

These springs occur on gentle (1°) western or southern slopes at an altitude of 718–732 m a.s.l. Soil texture is sandy with small-to-medium rocks with a rock cover of 10–20 %.

Shrub cover is 60 % and the herbaceous layer has a coverage of 30 %.

The forb, Species 814 (sent in to herbarium for identification), and succulent *Crassula biplanata* are diagnostic species (species group N). The shrub *Rhus pallens* and grasses *Pennisetum macrourum* and *Ehrharta*

erecta (species group E and K) are locally prominent.

Floristic analysis of springs on the

Kammanassie Mountain

A total of 244 plant species were recorded for spring flora, representing 145 genera and 71 families (Table 2). Flowering plants are represented by Monocotyledoneae with 63 species in 7 families and Eudicotyledoneae with 156 species in 43 families. The Pteridophytes, with 12 species in 8 families and 12 species in 12 families of Bryophytes (mosses) represent the non-flowering plants. Only one species of gymnosperm was found. A ratio of 6:1 dicotyledon species to monocotyledon species was found for the spring flora.

Seven families dominate the flora found at springs on the Kammanassie Mountain. The two largest families are the Asteraceae with 41 species, reflecting 14.5 % of the total flora and the Poaceae with 25 species (8.8 % of the total flora) (Fig. 4). These are followed by much smaller, yet significant families, represented by the Cyperaceae with 19 species (6.7 % of the total flora), Restionaceae with eight species (2.8 % of the total flora), Juncaceae with six species (2.1 % of the total flora), Rosaceae with six species (2.1 % of the total flora) and Scrophulariaceae also with six species (2.1 % of the total flora) (Fig. 4).

Two red data species were found, representing 1 % of the flora of springs on the Kammanassie Mountain. The endangered *Erica* sp nov (Ericaceae) was sampled at sample plot 18 (Kamm/w/19) and the rare *Agathosma affinis* (Rutaceae) in sample plot 24 (Kamm/w/25). Both these two springs dried up before the KKRWSS started abstraction.

A total of 11 alien species or cosmopolitan weeds were found at springs on the Kammanassie Mountain.

Geological origin of spring plant

communities

The springs within the *Hippia frutescens-Helichrysum* shrubland (plant community 1.1) are all springs emanating at a perched water table of the Nardouw/Cedarberg Formation, while springs within the *Hippia frutesens-Helichrysum petiolare* shrubland (plant community 1.2) are all emanating at perched water tables on the Nardouw/Kouga Formation. Springs of the *Hippia frutescens-Ehrharta* species grassland (plant community 1.3) has its geological origin at shallow springs emanating at perched water tables on Cedarberg shale and Peninsula Formation. Thus all the springs within the *Blechnum tabulare-Hippa frutescens* fern (plant community 1) have their geological origin at shallow, perched springs.

The *Eragrostis plana-Juncus lomatophyllus* grassland (plant community 2) has a mixed geological origin, emanating from the Nardouw Formation and the Kouga/Baviaanskloof Formation that is in close contact with the Bokkeveld Group. All these springs originates predominantly from the Nardouw Formation with Cedarberg shale contact.

The nine springs found in the *Berzelia intermedia-Psoralea verrucosa* shrubland (plant community 3) are all shallow and perched, with six emanating from the Nardouw/Cedarberg Formation, one from the Nardouw/Kouga Formation, and two from the Peninsula Formation.

A total of five of the seven springs of the *Cliffortia ilicifolia-Stoebe plumose* shrubland (plant community 4) has a predominantly Nardouw/Kouga Formation geological origin. Other origins include the Nardouw Formation with combined lithological and structural control. Therefore, the dominant geological origin is from the Nardouw Formation.

The *Ehrharta ramosa-Aspalatus kougaensis* shrubland (plant community 5) springs have their geological origin from the Nardouw Formation. Springs from the *Conyza canadensis-Conyza scabrida* shrubland

Table 2
An alphabetical list of plant families, collected at springs on the Kammanassie Mountain, indicating the number of genera and species in each family

Families	Genera	Species	Families	Genera	Species
Bryophytes			.../Eudicotyledons		
Aneuraceae	1	1	Apocynaceae	1	1
Bartramiaceae	1	1	Araliaceae	2	2
Brachytheciaceae	1	1	Asteraceae	19	42
Bryaceae	1	1	Brassicaceae	1	1
Dicranaceae	1	1	Bruniaceae	1	1
Fissidentaceae	1	1	Campanulaceae	2	2
Grimmiaceae	1	1	Caryophyllaceae	4	4
Hedwigiaceae	1	1	Celastraceae	2	3
Jungermanniaceae	1	1	Convolvulaceae	1	1
Pallaviciniaceae	1	1	Crassulaceae	2	5
Pottiaceae	1	1	Dipsacaceac	1	1
Sematophyllaceae	1	1	Droseraceae	1	1
	12	**12**	Ebenaceae	2	3
Pteridophytes			Ericaceae	1	13
Aspleniaceae	1	2	Euphorbiaceae	1	1
Blechnaceae	1	2	Fabaceae	9	14
Dennstaedtiaceae	1	1	Geraniaceae	1	5
Dryopteridaceae	1	1	Gunneraceae	1	1
Gleicheniaceae	1	1	Lamiaceae	4	5
Hymenophyllaceae	1	1	Linaceae	1	1
Pteridaceae	1	3	Malvaceae	2	3
Thelypteridaceae	1	1	Menispermaceae	1	1
	8	**12**	Molluginaceae	1	1
Gymnosperm			Moraceae	1	1
Taxodiaceae	1	1	Orobanchaceae	1	1
	1	**1**	Oxalidaceae	1	1
Monocotyledons			Polygalaceae	2	3
Araceae	1	1	Primulaceae	1	2
Cyperaceae	9	19	Proteaceae	2	3
Dioscoreaceae	1	1	Ranunculaceae	1	1
Iridaceae	3	3	Rhamnaceae	1	1
Juncaceae	1	6	Rosaceae	2	6
Poaceae	13	25	Rubiaceae	1	1
Restionaceae	6	8	Rutaceae	2	4
	34	**63**	Salicaceae	2	2
Eudicotyledons			Santalaceae	1	1
Aizoaceae	2	2	Sapindaceae	1	1
Anacardiaceae	1	3	Scrophulariaceae	3	6
Apiaceae	2	2	Solanaceae	1	2
			Urticaceae	1	1
				90	**156**
			Total	**145**	**244**

(plant community 6) have a mixed geological origin, with two springs originating from the Nardouw Formation and one shallow, perched spring on Cedarberg shale. The springs from the *Phragmites australis* reed community (7), the *Ehrharta erecta-Rhus pallens* shrubland (plant community 8) and *Pelargonium radulifolium-Salvia namaensis* (plant community 10) originate on the Nardouw Formation-Kouga/Baviaanskloof Formation close to the contact with the Bokkeveld Group. These plant communities, therefore, have similar geological origins.

Plant community 9, *Mentha longifolia-Thelypteris confluens* shrubland, originates from the Nardouw Formation while the *Ehrharta erecta-Crassula biplanata* shrubland (plant community 11) has two springs, both shallow and perched, on Cedarberg shale.

Discussion

A total of 244 plant species were found at 52 springs on the Kammanassie Mountain, representing 145 genera and 71 families. Of the 71 plant families, one gymnosperm, eight families of pteridophytes (11 %), 12 families of bryophytes (mosses)(17 %), seven families of monocotyledoneaes (10 %) and 43 families of dicotyledons (60 %) were recorded for the spring vegetation. The high presence of Asteraceae (14.5 % of the total flora) corresponds to Goldblatt & Manning (2000) and was similar to the Vermaaks, Marnewicks and Buffelsklip Valley floristic composition which had 16 % Asteraceae present (Cleaver 2004). Cyperaceae (6.7 % of the total flora) with 19 species and Restionaceae (2.8 % of the total flora) were the second and third most dominant families present at the springs on the Kammanassie Mountain.

The ratio of 6:1 dicotyledon to monocotyledon species observed for the spring flora compares well to that of the spring flora at Fernkloof Nature Reserve (four dicotyledons to one monocotyledon species) also situated in Mountain Fynbos vegetation (Mostert 2003). This ratio of spring flora for Kammanassie Nature Reserve (6:1) is also higher than the ratio of 3:1 for the Cape Floristic region as given by Goldblatt & Manning (2000). However, the species richness for the Kammanassie Mountain springs is 47 species/100 m² compared to the much higher 126 species/100 m² for Fernkloof Nature Reserve (Mostert 2003). A possible explanation for this could be that the springs of the Fernkloof Nature Reserve are mainly situated on moist southern slopes (Mostert 2003) whereas a large number of springs on the Kammanassie Nature Reserve are located on drier northern slopes. This, together with the higher average annual rainfall of 674 mm for the Fernkloof Nature Reserve, compared to the average annual rainfall of 450 mm for the Kammanassie Mountain can explain the higher species richness found at Fernkloof Nature Reserve.

The *Cliffortia ilicifolia-Stoebe plumosa* shrubland represents springs that dried up before 1993. These springs are also perched and comprise drier shrubland vegetation, with grasses prominent. Both the rare *Agathosma affinis* (Rutaceae) and endangered *Erica* sp nov (Ericaeae) occur within this plant community, making it an important plant community to manage and conserve. The *Erica* sp nov, an endangered species, also occurs within the *Ehrharta erecta-Rhus pallens* community.

Flowing springs and the ones that have water have very different plant communities to those that are dry. A difference in plant species composition was also found between springs that have been drier longer than others. The species composition of flowing springs differ strongly with those of drier springs in that ferns, mosses and water plants dominate these communities.

Springs that have been dry for a number of years, have a shrub, grass and restio dominance while springs that have dried up recently (within the last 3 years) show a distinct difference, with no shrub layer present and the herbaceous layer being dominant.

There is a strong relationship between spring geological origin and plant communities

found at springs, whether shallow perched type springs on the Nardouw/Cedarberg or Nardouw/Kouga contacts, Nardouw Formation with combined litological and structural control or Nardouw Formation-Kouga/Baviaanskloof Formation close to the Bokkeveld Group.

Spring (Kamm/w/09) of the *Mentha longifolia-Thelypteris confluens* shrubland (plant community 9), dried up in September 1999, but still (three years later) has similar vegetation as the other flowing springs within this community. A possible explanation for this could be that this spring (Kamm/w/09, 635 m a.s.l.) occurs in the alluvium of the Vermaaks Valley and is not a perched spring. The water table, obtained from a monitoring hole close to this spring, was found to be approximately 5 m below surface (Cleaver *et al*. 2003). Therefore, although this spring stopped flowing at surface the water table at this spring is at a sufficient level to sustain the wetter plant community found at this site. Springs Kamm/w/08 (1135 m a.s.l.) and 22 (1404 m a.s.l.) also originate at the Cedarberg Shale contact between the Peninsula and Nardouw Formations and dried up in 1999. These two perched springs have a drier plant community, completely reliant on rainfall, as the water table is not within reach of the plants at such high-altitude springs. It is interesting that the plant community at spring Kamm/w/09 has not changed sufficiently to fall within a drier type community. Should the water table at this spring decline it could result in a change of the present plant community and further monitoring is essential at this spring to better understand the relationship between the water table and plant community present.

Conclusion

No similar vegetation descriptions have previously been carried out on the springs of the Kammanassie Mountains. This research therefore provides valuable data on these ecosystems.

The plant species identified from this study can now be included into the Kammanassie Nature Reserve Management Plan and will result in a more comprehensive plant species list for the reserve. The localities and plant communities within which previously unknown, rare, and vulnerable plant species occur were identified during this survey.

The wetness of a spring, period of time the spring had been dry and a spring's geological origin have influenced plant community composition of the springs on the Kammanassie Mountain.

If more springs dry up on the mountain, plant communities at these springs could change over time and species diversity could be expected to decrease as is the case with the dry and wet communities of this study. Important water dependent plants will be lost and 'wetland' plant communities will be transformed into dry shrub and grass dominated areas. The time it takes for these changes in plant species composition to form another plant community will, however, have to be determined through long-term monitoring of the different springs on the Kammanassie Nature Reserve.

These vegetation surveys and descriptions provide baseline information that allows similar surveys to be conducted in future. These monitoring data could then be compared with this study to determine if changes/shifts in plant communities have occurred. Since a change in habitat conditions will result in the loss of not only 'wetland' plant communities, but a host of other organisms such as invertebrates, frogs and fish species that depend on these plants for their existence, will also disappear. This will result in a reduction of flora and fauna biodiversity. The WCNCB should therefore continue to monitor rare and vulnerable species found during this survey to ensure their survival by applying the correct management strategies. Monitoring of spring vegetation should continue to determine changes in plant communities over time related to springs drying up. This could form part of a

long-term monitoring programme on the Kammanassie Nature Reserve.

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