NITROGEN, SODIUM, AND POTASSIUM IN FOLIAGE FROM SOME ARID- AND TEMPERATE-ZONE SHRUBS*

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Species of Chenopodiaceae contribute much of the perennial plant biomass over large tracts of the southern Australian arid zone. In some places they contribute almost all of it. Known as "saltbushes" for their high salt contents (Audas 1917), they were regarded by Cannon (1921) as halophytes. Osborn and Wood (1923) showed that these were not halophytes, but rather salt-accumulating plants growing commonly in soils of ordinary salinities. Miscellaneous analyses (Russell 1947) showed that these plants often have high protein contents in their foliage, and Trumble (1932) demonstrated a high nitrogen requirement for *Atriplex semibaccatum*, excessive for pasture cultivation of the species.

This present communication concerns foliage nitrogen, sodium, and potassium contents of some arid-zone chenopods and ecologically associated shrubs, obtained from the same places at the same times.

Methods

Vegetation was sampled in January near Mount Mary and on Morgan Common, both in South Australia, under average annual rainfalls of 9 in., on brown calcareous soils (for details of the region, see Jessup 1948). Samples from sclerophyll forest shrubs were taken at Upper Sturt, S.A. (see Specht and Perry 1948), for comparative purposes. At each place, a circular half-acre area was selected for minimum habitat variability. Voucher specimens of prominent shrubs were determined, and shoots sampled as the nearest to random points. Samples consisted of total foliage from the distal to the proximal leaf on the shoot axis. Samples, dried and milled, were analysed for nitrogen by a Kjeldahl analysis (1-g subsamples, replicate determinations within 2%), and for sodium and potassium by flame-photometry (0·5-g subsamples extracted with 0·1N HNO_3). Results are expressed as a percentage of oven dry weight.

Results

Analyses are listed in Table 1.

Figure 1 shows the relationship between sodium and Kjeldahl nitrogen contents of Morgan Common samples. *Kochia triptera* was exceptionally high in sodium and is discussed separately. In the range up to 5% sodium, the variables are correlated, but since all chenopod samples had high values, the correlation ($r = 0 \cdot 76$, $t = 4 \cdot 7$, d.f. = 17, $P < 0 \cdot 001$) is spurious except as a demonstration of difference between chenopod and non-chenopod samples, in both sodium and nitrogen contents. Correlations within each of these groups are not significant, although significance is approached in the chenopod group ($r = 0 \cdot 64$, $t = 2 \cdot 01$, d.f. = 6, $0 \cdot 1 > P > 0 \cdot 05$).

* Manuscript received April 13, 1967.

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TABLE 1

SOURCES AND ANALYSES OF FOLIAGE

Results are expressed as percentage of oven dry weight

Species	Locality	Sodium	Potassium	Nitrogen
Acacia myrtifolia (Sm.) Willd.	Upper Sturt	0·07	0·49	1·40
Acacia oswaldii F. Muell.	Mount Mary	0·30	0·60	1·58
Acacia pycnantha Benth.	Upper Sturt	0·15	0·89	1·99
Acrotriche fasciculiflora (Regel) Benth.	Upper Sturt	0·09	0·33	0·94
Astroloma humifusum (Cav.) R. Br.	Upper Sturt	0·04	0·26	0·77
Atriplex stipitata Benth.*	Morgan Common	3·20	2·40	2·17
	Morgan Common	2·80	2·20	1·90
	Morgan Common	2·80	1·30	1·83
Banksia marginata Cav.	Upper Sturt	0·30	0·22	0·67
Bassia patenticuspis R. H. Anderson*	Morgan Common	1·50	0·69	1·76
Billardiera cymosa F. Muell.	Upper Sturt	0·10	0·79	1·00
Bursaria spinosa Cav.	Upper Sturt	0·11	1·10	1·11
Cassia nemophila var. *coriacea* (Benth.) Symon.	Morgan Common	0·11	0·85	1·62
	Morgan Common	0·09	0·90	1·72
	Morgan Common	0·09	0·74	2·10
	Mount Mary	0·07	0·56	1·93
Cassia nemophila var. *platypoda* (R. Br.) Benth.	Morgan Common	0·02	0·62	1·83
	Morgan Common	0·04	1·60	1·51
	Morgan Common	0·10	0·34	1·47
	Morgan Common	0·10	0·62	1·09
Casuarina cristata Miq.	Mount Mary	0·07	0·34	1·11
Chenopodium nitrariaceum F. Muell.*	Mount Mary	3·50	0·92	1·65
	Mount Mary	0·70	0·92	1·43
Daviesia brevifolia Lindl.	Upper Sturt	0·05	0·76	1·19
	Upper Sturt	0·05	0·53	1·05
Enchylaena tomentosa R. Br.*	Morgan Common	4·20	1·40	2·73
Epacris impressa Labill.	Upper Sturt	0·05	0·42	0·63
Eremophila glabra (R. Br.) Ostenf.	Mount Mary	0·80	0·68	1·91
Exocarpos aphyllus R. Br.	Upper Sturt	0·29	0·83	0·94
Geijera linearifolia (DC.) J. M. Black	Mount Mary	0·18	1·30	1·85
Grevillea huegelii Meissn.	Mount Mary	0·15	0·24	0·62
Grevillea lavandulacea Schlecht.	Upper Sturt	0·09	0·40	0·63
Hakea ulicina R. Br.	Upper Sturt	0·12	0·37	0·34
Heterodendrum oleaefolium Desf.	Mount Mary	0·05	1·10	2·68
Hibbertia stricta R. Br.	Upper Sturt	0·13	0·28	0·73
Kochia brevifolia R. Br.*	Morgan Common	4·00	1·70	2·97
Kochia sedifolia F. Muell.*	Mount Mary	4·30	0·14	2·95
	Mount Mary	2·40	0·68	2·18
Kochia triptera Benth.*	Morgan Common	9·00	1·50	2·56
	Mount Mary	8·00	1·10	2·70
Lepidium leptopetalum F. Muell.	Morgan Common	0·80	0·74	2·28
Leptospermum juniperinum Sm.	Upper Sturt	0·16	0·30	0·76
Leucopogon virgatus (Labill.) R. Br.	Upper Sturt	0·05	0·29	0·52
Lycium ferocissimum Miers.	Morgan Common	5·0	0·98	2·50
Melaleuca lanceolata Otto.	Morgan Common	0·60	0·40	1·37
Myoporum platycarpum R. Br.	Morgan Common	0·70	1·50	1·48
Pultenaea daphnoides Wendl.	Upper Sturt	0·20	0·58	1·74

TABLE 1 (*Continued*)

Species	Locality	Sodium	Potassium	Nitrogen
Rhagodia spinescens R. Br.*	Morgan Common	2·50	3·20	2·70
Scaevola spinescens R. Br.	Mount Mary	0·50	0·58	1·34
Templetonia egena (F. Muell.) R. Br.	Mount Mary	0·08	0·70	2·12
Tetratheca pilosa Labill.	Upper Sturt	0·08	0·40	0·67
Westringia rigida R. Br.	Mount Mary	0·05	0·42	1·00
Xanthorrhoea australis R. Br.	Upper Sturt	0·09	0·74	0·59
Zygophyllum auranticum Lindl.	Morgan Common	1·10	0·60	1·93

* Chenopodiaceae.

Including the Mount Mary samples, which exhibited essentially similar relationships, the difference between chenopods and non-chenopods becomes less clear cut. [*Lycium ferocissimum* (Solonaceae)* had high values; one sample of *Chenopodium*

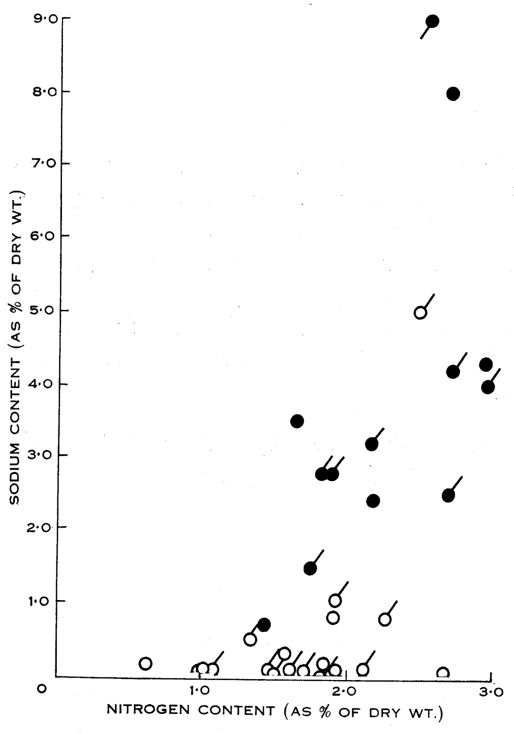

Fig. 1.—Relationship between sodium and nitrogen contents of samples from Morgan Common (circles with tails) and Mount Mary (circles without tails). ○ Non-chenopods. ● Chenopods.

nitrariaceum (Chenopodiaceae) had low values.] However, the correlation within chenopods (excluding *K. triptera*) becomes significant (Fisher's arctanh transformation, $Z = \text{arctanh}\, r = 0 \cdot 9$, $r = 0 \cdot 72$, $P < 0 \cdot 001$; or assuming equal variances in both samples and pooling directly, $r = 0 \cdot 72$, $P < 0 \cdot 05$).

* Exotic (South African) species.

Comparison (Fig. 2) of the non-chenopod samples with samples from Upper Sturt vegetation shows that many arid-locality non-chenopods attain appreciably higher sodium values than do Upper Sturt samples, and others do not. Those that do are in the high end of the nitrogen range.

Overall, there is evidence that elevated sodium content is accompanied by higher Kjeldahl nitrogen content in foliage of these arid-zone shrubs. Although high nitrogen content may be attained with low sodium content, the reverse appears not to happen. Saltbushes here are just as notably protein bushes. This suggests that the capacity of saltbushes to sustain high sodium contents depends on them having a very proteinaceous leaf.

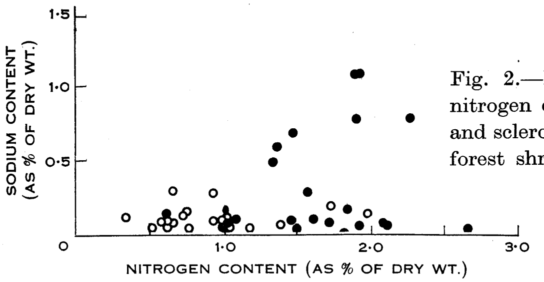

Fig. 2.—Relationship between sodium and nitrogen contents of samples from arid-zone and sclerophyll forest regions. ○ Sclerophyll forest shrubs. ● Arid-zone non-chenopods.

Numerous shrubs in the same habitat as these chenopods had foliage sodium contents no greater than those of sclerophyll forest shrubs on a sandy podzol, emphasizing the remarkable accumulating capacities of the chenopods. The relationship between potassium and Kjeldahl nitrogen contents of the arid zone samples was similar to the sodium–nitrogen relationship. Chenopod samples tended to have higher values for both variables than did non-chenopods. The relationships of chenopods to nitrogen balance in natural communities is of particular interest, and further study of this aspect is warranted.

The author wishes to thank Mr. W. Venables for help with statistics. The work was done with support from the Rural Credits Development Fund.

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Corrigendum

Volume 20, Number 4, August 1967

The captions to Figures 1 (p. 739) and 3 (p. 745) are correct as they stand but the figures themselves should be interchanged. The correct arrangement for Figure 1 is as follows:

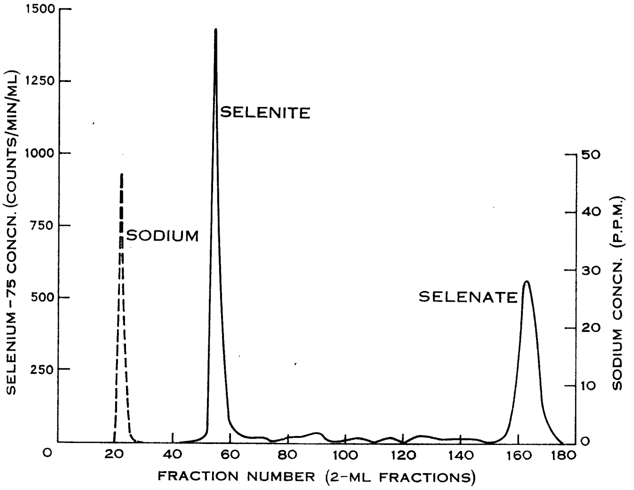

Fig. 1.—Separation of a mixture of sodium [^{75}Se]-selenite and sodium [^{75}Se]-selenate by anion-exchange chromatography on Dowex 1-X8 resin in the sulphate form.

The correct arrangement for Figure 3 is as follows:

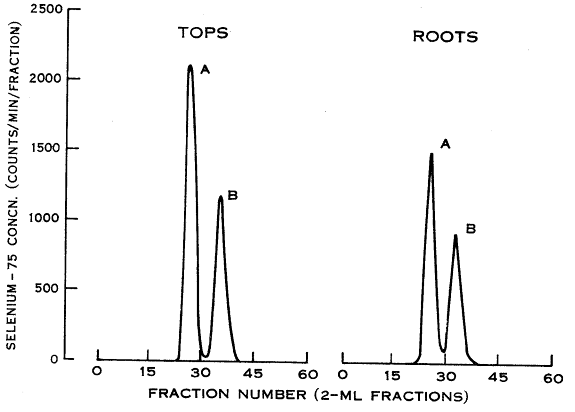

Fig. 3.—Separation of water-soluble volatile selenium compounds obtained from *M. sativa* tops and roots by anion-exchange chromatography on Dowex 1-X8 resin in the sulphate form.