Some Notes on *Suaeda australis* Moq. var. *nova zelandica* var. nov. and *Mesembryanthemum australe* Sol. ex Forst. f.

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Summary

Suaeda australis plants in New Zealand differ from those in Australia, and it is proposed to treat them as a new variety, var. *nova zelandica*. Seeds of these plants and of *Mesembryanthemum australe* do not germinate satisfactorily in a salt solution stronger than 1%. *Suaeda* seeds also have a low viability. Water-logging does not bring about the death of *Suaeda* plants unless the concentration of salt in the water exceeds 1%. In *Suaeda* the quantity of titratable acid appears to be low. In *Mesembryanthemum* there is a diurnal variation in the quantity of titratable acid, the maximum occurring just before sunset and the minimum just before dawn. These variations may be correlated with temperature rather than light, but if it is light it may be that malic acid (the principal acid in *Mesembryanthemum*) is a product of photosynthesis.

Introduction

The observations reported in this contribution formed part of a study of two maritime species. Other observations were made in addition, but either they were not conclusive or else were incomplete at the time when they had to be terminated through illness of the junior author. The main purpose was to study those factors which were likely to control the occurrence and distribution of *Suaeda australis* and *Mesembryanthemum australe*. It was further thought that there might be some relationship between the degree of succulence and the quantity of carboxylic acids. It was for this reason that a member of the Chenopodiaceae was compared with a member of the Aizoaceae. During the course of the investigation it became apparent that the taxonomic status of the *Suaeda* required investigation.

Taxonomic Status of the Suaeda Species Used in the Investigation

The plant was originally identified by Forster (1786) as *Salsola fruticosa*. In 1810 Brown described the Australian plant as *Chenopodium australe* but Moquin (1831) transferred it to *Suaeda*. Hooker, after comparing both Australian and New Zealand specimens with European material, decided they were all identical (as *S. maritima*) and this view was followed by Cheeseman (1906, 1925). Moss (1914) and Chapman (1947a) suggested that the plants from the southern hemisphere were probably specifically, or at least varietally, distinct from *S. maritima* of Europe. The European plant is commonly an annual, whereas the New Zealand and Australian plants are suffrutescent and are at

* The junior author died in May, 1952, before the work was completed. The senior author has compiled the account from the late Miss MacKay's notes and added some observations of his own. Some experimental work was not complete and the data could not be used.

least biennials, the Australian plants possibly existing even longer. Collins (1921), Paulsen (1918) and Cooper (1950) use the name *S. australis* and state that they consider it to be a species distinct from *S. maritima*.

We are in full agreement with this view and its correctness is confirmed by the experience of one of us (V. J. C.) with the northern *S. maritima*. There is, however, yet a further problem, and that is the question of the similarity between the New Zealand and Australian plants.

A comparison of plants found around Sydney with those found around Auckland is sufficient to show that the two are distinct. The Australian plant is coarser and larger than the New Zealand one, and is much more suffrutescent. In addition the leaves of the Australian plants are nearly twice the length of those of the New Zealand plants. Branching in the Australian plants tends to be erect, whereas in the New Zealand plants it tends to be spreading. The leaves of the New Zealand plants are arranged either alternately* or oppositely. Both arrangements occur on the same plant, and in this respect the plants differ from the European species where the leaf arrangement is wholly alternate.

Experimental work would be necessary in order to determine whether there are two separate species in Australia and New Zealand. The plants in the two countries can, however, scarcely be considered as identical, and pending additional evidence it is suggested that the New Zealand plant should be known as *S. australis* var *nova zelandica*. Historically it is clear that the specific name must be applied to the Australian plants.

S. australis (R. Br.) Moq. var. *nova zelandica* var. nov.

A biennial or perennial differing from the type (Australian) in the smaller size, branches more spreading, shorter, not so stout; leaves smaller, up to 1 cm. long and 1 5 mm. wide, more persistent than in type, arranged alternately and oppositely.

Salinity and Germination

The principal results are summarised in Table I.

Table I.

Per Cent. Germination of Seeds of *Suaeda* and *Mesembryanthemum*

% NaCl. (initial)	*Suaeda* A	B	C.	*Mesembryanthemum* D.	E.	F.
Tap water	17	6	—	62	38	29
0.02	11	7	11	62	100	36
0.25	6	10	13	57	85	47
0.5	14	8	7	54	91	30
0.75	4	10	—	58	92	36
1.0	7	10	—	?	63	53
2.0	1	0	—	2	0	2
3.0	0	0	—	0	0	0

A. 4 lots of 25 seeds on filter papeı in petri dishes. Time 2½ months
B. 2 lots of 50 seeds on filter paper in petri dishes. Time: 2 months.
C. 2 lots of 50 seeds on sand in petıi dishes. Time: 1½ months.
D, E. 2 lots of 50 seeds on filter paper in petri dishes Time: 2 months, 1 week.
F. 2 lots of 50 seeds on filter paper in petri dishes. Time: 1 month, 3 weeks

* Dr. L. H. Millener drew our attention to this feature.

In view of the fact that the chloride content of the solutions was not determined at the finish of the experiments, the only justifiable deduction from the data is that there is a substantial and significant drop in germination above 1% salt. It is also evident that *Suaeda* seeds are considerably less viable than those of *Mesembryanthemum.* In no one of the numerous experiments of various types did the per cent. germination of *Suaeda* rise above 30, whereas in *Mesembryanthemum* there were several results between 80–100% Low viability was also recorded by Chapman (1947a) working with the northern *S. maritima.*

As might be expected the sodium chloride operates osmotically by inhibiting the uptake of water. Seeds in the groups of experiments above which had failed to germinate after two months in 2% and 3% sodium chloride (the values may have been greater on account of evaporation) were transferred to tap water, when germination took place (Table II).

TABLE II.

Per Cent. Germination of Seeds of *Suaeda* and *Mesembryanthemum*

Initial	*Suaeda*		*Mesembryanthemum*		
Salt	A.	B.	C.	D	E.
2%	6	26	63	39	7.5
3%	20	26	72	77	18

A, E 2 lots of 50 seeds in each dish. Time· 1 month

B, C, D. 2 lots of 50 seeds in each dish. Time. 2 months.

These data demonstrate that the seeds of both species are unharmed by 2% and 3% NaCl, and germination is comparable with that obtained if placed first in tap water without immersion in salt water (Table I). These results are similar to those obtained by Sussex (1949) for *Aster subulatus* var. *euroauster.*

Growth and Drainage

It was thought that the relatively high position on the shore occupied by *Suaeda australis* might be related to intolerance of water logging. Experiments were therefore carried out to test this possibility Plants were grown in 3-inch pots and were planted so that the roots did not extend down for more than 1½ inches Two types of soil were used, (a) sand; and (b) salt marsh mud; and each soil was given four treatments:

(i) Allowed to drain naturally and watered daily

(ii) Water maintained at ½ inch above base of pot

(iii) Water maintained at 1½ inches above base of pot.

(iv) Water maintained at 2½ inches above base of pot.

In treatments ii-iv the pots were kept in glass battery jars. There were three plants for each treatment. The sand and mud soil groups were placed in two separate blocks in the greenhouse. At weekly intervals growth was measured by increase in height The experiment ran for about 1½ months. At its completion it was repeated using water containing first 1% NaCl, then 2% NaCl and finally 3% NaCl. The complete series was carried out for *Suaeda* but only the first group (pure water) had been performed for *Mesembryanthemum,* and these are therefore not discussed The results for *Suaeda* are set out in Table III.

TABLE III.

Average Growth of Each Group of Three Plants.

Height of plants (cms.)	SAND Free drainage.	½in.	1½in.	2½in.	MUD. Free drainage.	½in.	1½in.	2½in.
H_2O—								
Start	4.83	4.5	3.6	4.26	5.06	5.16	4.0	4.66
Finish	7.16	7.16	5.5	6.16	8.16	7.5	8.0	6.5
Increase	2.33	2.66	1.9	1.90	3.10	2.34	4.0	1.84
1% NaCl—								
Start	2.5	2.66	2.8	2.50	2.66	3.33	2.8	2.0
Finish	3.66	5.16	5.33	4.33	9.0	5.25	4.66	Dead
Increase	1.16	2.50	2.53 leaves dead ⅓ up	1.83 leaves dying	6.34	1.92 lower leaves dead	1.86 leaves dead ½-way	—
2% NaCl—								
Start	4.30	5.0	7.0	6.33	4.83	4.5	6.0	5.0
Finish	5.33	5.55	two dead no growth in third	8.0	6.66	Dead	Dead	Dead
Increase	1.03	0.5	—	1.67	1.83	—	—	—
3% NaCl—								
Start	4.3	4.66	4.5	4 16	2.5	2.83	3.16	2.83
Finish	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead

From the data it is clear that water-logging does not bring about death of the plants, and it may not even curtail growth. It was found that when the plants were removed at the end of the experiment the roots had all developed in the upper non-water-logged area. This corresponds to the aerated layer described by Chapman (1938) and the root development is also comparable to that described by Chapman (1934). It is clear from the experiments that the plant is sensitive to salt in the soil water because water logging in even 1% salt solution will bring about death, whereas water-logging in tap water will not. Salinity of the soil water is therefore regarded as the primary factor maintaining *Suaeda* at a level on the shore where the roots will not be subject to such conditions. The germination experiments suggest that *Suaeda* has a narrow range of tolerance to salt (0–1%).

ACID METABOLISM

A preliminary study of the acid metabolism, as represented by the Total Acid Number (T.A.N.) (see Thomas and Beevers, 1949), was made of both species. The T.A.N. is expressed throughout as c.c. 1/10 N Alkali required to neutralise acid from 1 gr. fresh tissue. The method employed was to boil the weighed tissue in water for 15 minutes, filter through powdered charcoal to decolorise, and titrate aliquots with N/50 caustic potash and calculate to N/10 basis. The results from *Suaeda* were inconclusive but those from *Mesembryanthemum* warranted further study. Hourly samples were therefore collected, ground up in a Waring Blendor with 10 c.c. distilled water and the acidity determined by a Cambridge pH meter. The results indicated a clear diurnal fluctuation in acidity (Figs. 1, 2), the maximum being reached at the end of the day and the minimum soon after sun-

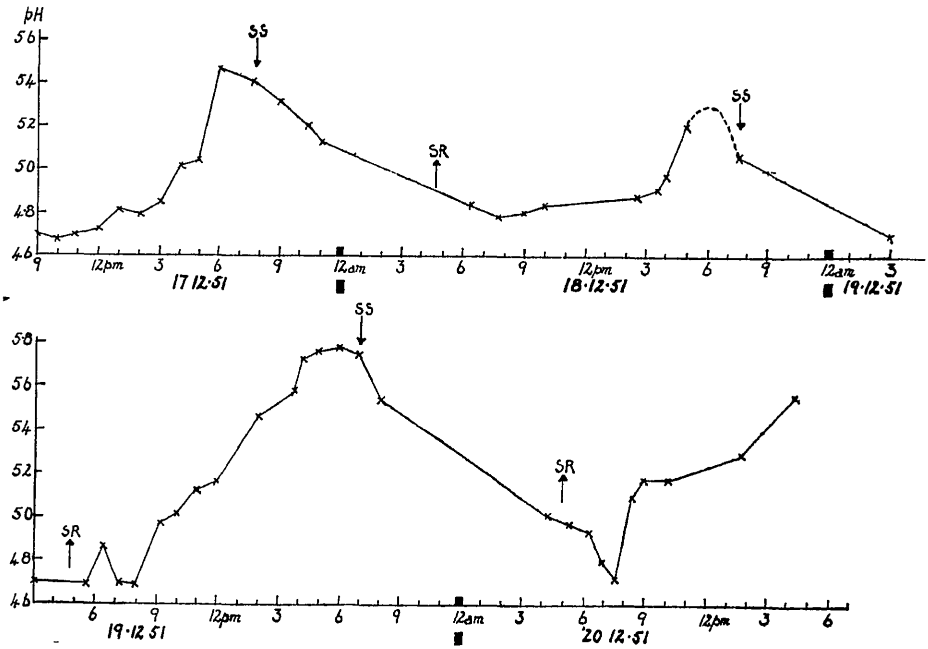

Fig. 1.—Diurnal variations of acidity in *Mesembryanthemum australe.* SS, sunset; SR, sunrise.

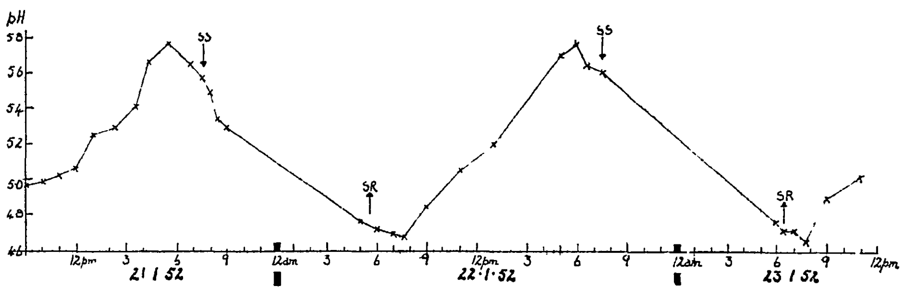

Fig. 2.—Diurnal variations of acidity in *Mesembryanthemum australe.* SS, sunset; SR, sunrise.

rise. In this respect the acid metabolism of *Mesembryanthemum* is the reverse of that of the Crassulaceae where the acid increases during darkness and decreases in the light.

Discussion

It is clear that neither species gives effective germination in salt concentrations exceeding 1%. Very similar conclusions were reached by Poma (1922) for *Aster tripolium, Salicornia europea, Puccinellia maritima, Triglochin maritimum* and *Juncus maritimus*, the seeds of which did not germinate in solutions containing more than 1 5% NaCl. In any case the seeds of *Suaeda australis* var. *nova zelandica* have a low viability. In both the species studied the inhibition of germination is due to failure to imbibe water, and Poma (*loc. cit.*) found the same phenomenon with the seeds of the plants he studied. He was able to show that a salt solution of O.P. 44 atmospheres would not kill the seeds and that germination ensued when they were put in tap water.

In view of the fact that water-logging has been shown to bring about the death of *Suaeda fruticosa* (Chapman, 1947b), it was interesting to find that this factor apparently does not operate with *S. australis* var. *nova zelandica.* In this species salinities in excess of 1% NaCl appear to be more potent as a controlling factor The restriction of plants to elevated shingle or shell ridges cannot therefore be a result of drainage requirements but may well be a result of intolerance of actual flooding of the roots by sea water. Because there is also an indication that the plants require some salt for satisfactory growth (it is hoped to prosecute this matter further), it can be appreciated why the plant may be restricted to a zone on the shore where there is no likelihood of root flooding but where the soil water table is likely to be brackish.

The experiments relating to acid metabolism showed that acids were not present in great quantity in *Suaeda,* and that those present did not exhibit any diurnal fluctuations. The information on the acidity of halophytes is meagre (Evans, 1932) but in those cases where it has been studied it has proved to be low and *Suaeda* conforms to this picture. In *Mesembryanthemum* there is a regular diurnal variation with the maximum occurring normally just before sunset and the minimum soon after sunrise. In the genus *Mesembryanthemum* the dominant acid is said to be malic (Evans, 1932) though oxalic also occurs. Diurnal variations are reported as occurring in the older leaves (Bendrat (1928) in Evans, *loc cit.*) but are absent in the younger leaves. According to Bennet-Clark (1932) there are no diurnal variations of acidity in leaves of *Mesembryanthemum,* but the age of the leaves may not have been considered. The leaves used in the present experiments would be regarded as old leaves and hence confirming the results of Bendrat. It is, however, pertinent to note that the acid changes are not those normally expected under a Crassulacean metabolism, where the acidity reaches a maximum in the dark and is reduced in the light

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