Sheep Production on Seeded Legumes, Planted Shrubs, and Dryland Grain in a Semiarid Region of Israel

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Highlight: During a period of 10 years in an area in which rainfall ranged between 170 and 413 mm, grain yields ranged between 0.8 and 3.6 tons per hectare. When grazing was combined with cropping, between 20 and 200 kg of lamb liveweight were produced per hectare at different stocking rates and in different years. Grazing the grain fields had left enough grain to be harvested only under stocking rates lower than 0.4 hectare per ewe in most years, and under stocking rates tighter than 0.2 ha/ewe only in a year in which ungrazed fields produced 3.5 tons of grain per hectare. Of several legume species tried in the same area, Medicago polymorpha and M. tribuloides (= M. truncatula) survived to form dense swards of 2-6 t/ha dry matter yields. After 3 years, legumes were largely replaced by ruderal annuals. This grass sward forms a highly palatable pasture with yields equaling those of the legumes, probably due to the high nitrogen build-up in the soil. At stocking rates of 0.4-0.6 ha/ewe, sheep could be maintained on this pasture without supplements the whole year round. Annual lamb yields ranged from 15 to 40 kg/ewe and from 40 to 80 kg/ha. Fertility disorders, apparently due to estrogenic activity in the medics, were recorded in one of the legume years. Native saltbush (Atriplex halimus) was planted at a rate of 1600 shrubs/ha as a range improvement technique. Shrub development was excellent and the shrubs soon formed a dense, impenetrable stand, crowding out most of the annual herbaceous grass and vegetation. Sheep performance on this vegetation was poor in comparison with unimproved native pasture.

The 200- to 400-mm rainfall belt in southern Israel—as in other regions bordering the desert—is a marginal cropping area. The farmer, primitive or modernized, tries to push grain farming as deep as possible into the arid zone (Nuttonson, 1955, 1957, 1961). This may be accomplished by integrating grain cropping with animal production (Oram, 1956; Rossiter, 1966).

The background and rationale for undertaking an investigation into such an operation in the northern (semiarid) Negev of Israel were described previously (Tadmor et al., 1974). That paper included a detailed description of the Migda experimental site, its climate, soil, and native vegetation. Results were given of the plant and sheep production on the native unimproved annual grassland. The present paper will give results of plant and sheep production from pastures improved with legumes and saltbush shrubs and from cereals in the same area.

Barley is the most common cereal crop in areas of less than 300 mm of rain (Nuttonson, 1955, 1957, 1961, 1962; Olson, 1958; Oram, 1956) and until recently, barley prevailed also in the northern Negev of Israel. Therefore, this was the cereal which was sown in the first 3 years of the present experiment. Due to national economic considerations, farmers in the area changed over to wheat, and this was done also in the experimental plots. The currently used commercial variety of wheat was the one always seeded.

One of the difficulties in cereal-sheep management in an area with frequent droughts arises from the fact that it is difficult to guess during the growing season how successful the grain crop will be. If the year is going to end up as a "good year," there should be enough growth on the pasture fields to support the sheep. Furthermore, it should seem wise to avoid any grazing on the grain field during the green season in order to exploit the full potential for grain production. If the year turns out to be "bad," the grain yield may be too small to justify the expenses of harvesting. Using the grain fields as green fodder in this case may be of great help, mainly for pregnant and lambing ewes. The optimal utilization of the grain fields will vary with the year (amount and distribution of rain) and with the stocking rate. The present experiment was therefore planned to include a series of stocking rates on cereal fields ranging from very intensive grazing where the crop in all years would be lamb alone, through intermediate to light intensities, where the weight of the crop would shift towards mixed lamb plus grain and to pure grain production.

The heavy fertilizing of the soil and seeding to legumes is not a common practice in an area of 250 mm rainfall or less.
However, the long cultivation history of the northern Negev Desert, with occasional records of high yields of grain, have encouraged the undertaking of this pasture improvement effort.

The idea of seeding legumes was founded in the belief that improvement of native pasture was necessary for pasture management in this area. Annual, self-seeding legumes were chosen, following Australian experience in higher rainfall areas. An annual plant was sought in order to avoid a plant's going through the summer drought period.

Saltbush species (Atriplex spp.) have been regarded as important pasture plants in 250- to 400-mm rainfall areas, at least as early as the middle of the 19th Century (Williams, 1960). Dixon (1880) suggested that in a climate subject to periods of continued drought, plants which have withstood the influences of hard grazing for ages past would be more reliable than others developed under different conditions. The possible role of saltbush in assuring a "more stable summer production" and thus reducing the fluctuations in the sheep populations were also discussed by Williams (1960).

Upon the establishment of the Migda experimental grazing site (Tadmor et al., 1974), it was decided to include in it special plots of Atriplex halimus, a plant native to the region and one which seemed to possess all the necessary attributes: evergreen, high nutrient value (Eyal and Benjamin, 1958; Tadmor and Lachover, 1967), extreme drought resistance, high productive potential, and sufficiently low palatability so as not to be grazed out easily.

Large areas of this shrub had already been planted in the Negev desert by the Soil Conservation Department. However, information on the forage value of these plants to animal production was not available, and it was considered most important to acquire the missing knowledge before the planted areas were further expanded.

It was not intended that any of these three pasture types should be grazed alone in practice; but in order to obtain data on seasonal primary production, and the possible contribution of each type to secondary production, each type had to be separated at this stage. Combined grain, legume, and shrub grazing were to be manipulated at a later stage.

Materials and Methods

Experimental Layout

A detailed description of the experiment and its phases was given by Tadmor et al. (1974). Two plots of 4.8 ha each and two plots of 9.6 ha were allocated to each of the three vegetation types. The cultivation methods and stocking rates applied were as follows:

**Grain**

The plots were maintained on a worked fallow-grain rotation throughout the whole period. Each plot was divided into two equal subplots and only half the area was sown. Grain and fallow were rotated annually. Phosphate and nitrogen fertilization were given at rates which supplied 40 kg P₂O₅ and 40 kg pure N/ha at sowing time and an additional 20 kg N as top dressing.

Eight Mutton Merino sheep were kept in each plot during phase I of the experiment for two stocking rate replicates of 0.3 ha/ewe and 0.6 ha/ewe. In phase II the plots were subdivided for six stocking rates (without replicate of 0.05, 0.15, 0.2, 0.3, and 0.4 ha/ewe). The experimental flocks during this phase were composed of 12 ewes—six Mutton Merino and six Awassi (fat-tailed) each. It should be noted that the stocking rates were calculated for the sown area only.

For economic evaluation of the results the fallow part of each plot must also be taken into consideration.

A 100 m² area was exclosed in each plot to evaluate the yield of grain and straw without grazing. For about 3-4 months (November-February) of each year the sheep had to be withdrawn from the plots to enable cultivation and growth after germination. During this period sheep were yanked and fed straw and concentrates at levels adjusted to maintain body condition at the time of withdrawal.

**Legume Pasture**

Legumes were seeded in November-December 1963 after careful seedbed preparation. The seedbed was first deeply rooted, then disced even, disced again after the first rain to eradicate weeds, heavily fertilized with 240 kg/ha P₂O₅, and then drilled and rooled to produce an even seedbed. Several mixtures of different quantitative makeup were used; all included Vicia dasyycarpina (pseudovetch), lana vetch, Medicago polymorpha (burr clover), Medicago truncatula (= M. tribuloides, = barrel medic, both native and Australian), Trifolium purpureum (red clover), and Lolium rigidum (annual Wimmera ryegrass). Seed was drilled in to a depth of 2-5 cm at a rate of 20-30 kg/ha. These rates are much higher than those cited by Australian investigators (Andrew, 1962; Donald, 1951). The careful seedbed preparation and dense seeding proved itself. A full germination and vigorous growth followed. In the spring of 1964, Vicia dasyycarpina dominated the sward, and gave very high yields. This ungrazed sward (no sheep in 1963/64) was harvested for seed in April 1964. In order to ensure reseeding of the lana vetch, this harvesting was carried out with wide open combine vents, which resulted in 120-200 kg/ha of vetch seed being spilled back on the area in addition to a seed crop of 600 kg/ha. Discing in of the dry sward in the summer of 1963 resulted in an excellent almost pure legume sward in the next season, 1964/65. While Vicia again completely dominated the swards, other species were present. Grazing began in the spring of 1965, and while some Vicia flowers were consumed, probably 70 to 80% were left intact because of the wealth of plant bio-mass. In addition to grazing, about 45 tons/ha of hay were baled that year.

Discing was discontinued in 1965 to allow sheep to graze the Vicia and other legume stubble. The next season, 1965/66, Vicia no longer dominated the sward and subsequently disappeared, while Medicago polymorpha and M. truncatula became dominant for 4 years until the spring of 1969 (Fig. 1, middle).

In Phase I (preliminary) flocks of eight ewes each were kept for 3 years at two stocking rates (0.6 and 1.2 ha/ewe) in two

<table>
<thead>
<tr>
<th>Year</th>
<th>Rainfall</th>
<th>Cereal yield</th>
<th>Legume yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>64/65</td>
<td>377(g)</td>
<td>2.2</td>
<td>6.8</td>
</tr>
<tr>
<td>65/66</td>
<td>413(g)</td>
<td>3.6</td>
<td>4.0</td>
</tr>
<tr>
<td>66/67</td>
<td>218(b)</td>
<td>0.9</td>
<td>2.1</td>
</tr>
<tr>
<td>67/68</td>
<td>282(g)</td>
<td>3.3</td>
<td>6.2</td>
</tr>
<tr>
<td>68/69</td>
<td>208(b)</td>
<td>1.5</td>
<td>4.1</td>
</tr>
<tr>
<td>69/70</td>
<td>224(b)</td>
<td>1.8</td>
<td>4.9</td>
</tr>
<tr>
<td>70/71</td>
<td>170(b)</td>
<td>0.8</td>
<td>1.3</td>
</tr>
<tr>
<td>71/72</td>
<td>238(b)</td>
<td>2.0</td>
<td>1.9</td>
</tr>
<tr>
<td>72/73</td>
<td>350(g)</td>
<td>3.5</td>
<td>7.2</td>
</tr>
<tr>
<td>73/74</td>
<td>258(b)</td>
<td>2.6</td>
<td>--</td>
</tr>
</tbody>
</table>

*(g) for good intraseasonal distribution, (b) for bad.*

1. In the first 3 years the grain crop was barley; in the following years it was wheat.
2. Includes baled straw only. Stubble left in the field was estimated in some years only and amounted to a quantity similar to that of the baled straw.
replicates. In Phase II (main experiment) there were six stocking rates: 0.1, 0.15, 0.2, 0.3, 0.4, and 0.6 ha/ewe. The number of sheep was equal in all plots and plot size varied between 1.6 and 9.6 ha.

In Phase I German Mutton Merino ewes (purchased as hoggets in 1965) were used (Fig. 1, top). In Phase II groups of 16 ewes were kept as closed flocks. The sheep were brought in from flocks of unknown history and some of them had to be replaced in the course of the experiment due to poor performance. There were eight German Mutton Merino (6-7 ewes and 1-2 hoggets) and eight Awassi fat-tail sheep in each treatment. There was a fence dividing the two breeds within each plot.

**Shrubs**

*Artemisia halimus* seedlings were prepared in 30-cm deep, 10-cm diameter plastic bags and raised in the nursery for 4-6 months until they reached a height of 20-30 cm. At the beginning of January 1964, plants were transferred to the field and planted with a semi-mechanized planter at a rate of 1600 plants/ha with 3 m between rows and 2 m in the interrow distance. Seedbed preparation prior to planting had consisted of rooting and discing to smooth out the seed bed. Seeding establishment was excellent—about 95%. To control competing weeds in the year of establishment, two inter-row discings were carried out in the spring of 1964. Twelve ewes (mixed Mutton Merino hoggets and Corriedale ewes) were introduced into each plot in February 1965 and kept until October 1967, forming stocking rates of 0.4 or 0.8 ha/ewe. Saltbush grazing was carried out in the preliminary trial only (Tadmor et al., 1974), after which it was discontinued as discussed later. The stocking rates were gradually reduced during the second year to 0.8 and 1.6 ha/ewe.

**Results and Discussion**

**Primary Production**

**Grain**

Dry grain and straw production is shown in Table 1. Grain yields fluctuated between 0.8 and 3.5 t/ha. (The exceptionally dry season of 62/63, with only 42 mm rainfall and no germination, has been omitted from the table.)

In the 12 years of the experiment, grain yields fluctuated from zero to a record of 3.5 t/ha grain, through all the intermediate range. The straw component of the yield is composed of both baled (measured) straw and stubble—a very substantial part of the crop—which was measured only in some years.

The high productivity of the grain plots may be attributed to the heavily fertilized condition 40-60 kg N/ha, applied as ammonium sulphate or urea, and 40 kg/ha P<sub>2</sub>O<sub>5</sub>, applied as superphosphate). The grain fields thus compare in productivity with the legume swards. The fact that even in drought years there was a large enough yield to be worth harvesting must be attributed to the water conserving effect of the fallow-grain rotation. In other fields in which the grain was sown on turned up pasture, whether native or sown, the grain yields were less than half those of the fallow-grain in the drought years.

**Legume Development**

The very careful seedbed preparation and the extremely high seeding rate were essential for good establishment of the legumes. As preliminary field experiments and subsequent sowings over the years have shown, these two factors determine the successful establishment of legume pastures,
legume years (Fig. 1, middle). In drought years the actual yields will be small. Seed production, however, may be expected to be sufficient to ensure the sustenance of the legume pasture, together with hard seed stored from previous years. Yields in relation to rainfall are given in Table 1. High yields equal or surpass the results obtained in Australia under higher rainfall conditions (Andrew, 1962; Andrew and Hudson, 1954; Rossiter, 1966; Rossiter and Ozanne, 1970). The reason may be the good soil conditions at the Migda site. The disappearance of *Vicia* from the mixture may be explained by the fact that when discing was discontinued, the large *Vicia* seeds did not penetrate the ground, but lay on top and were eaten (and digested) by sheep, mice, and ants.

By the end of three legume years, in 1966, a very high soil fertility had accumulated; 550 ppm of nitrogen (NO₃⁻) was found by the phenol-disulfonic-acid method in the upper 0- to 30-cm layer of the soil in one of the legume plots. In 1968, the NO₃⁻ content in the upper 30 cm in four plots ranged between 140 and 460 ppm. This amounts to 120 to 400 kg N/ha, not counting the deeper layers, or other nitrogen sources. For discussions of soil nitrogen accumulation by legumes, see Purchase et al. (1949) and Rossiter and Ozanne (1970).

The high build-up of nitrogen caused the legumes first to decrease in 1967/68, and then to disappear almost completely in 1968/69. In their stead, a dense grass sward developed dominated by the ruderal *Hordeum murinum* with some *Brachypodium pinnatum* and remnants of the legumes. This sward had been dominant since 1969. Although these swards are now wholly grass, they are still referred to as "legume pasture" in this paper. Because of the high fertilizer residue, their primary production is almost double that of the native non-legume pastures. For a discussion of legume replacement by grasses, see Rossiter and Ozanne (1970) and Stern and Donald (1962). The latter authors suggest that, among other factors, the shading of legumes by taller grasses might be a main factor in the legume-grass succession.

**Shrub Development**

Weed eradication during the year of establishment, together with the two high rainfall years of 1963/64 and 1964/65, were responsible for the high rate of establishment of saltbush and for its fast growth. The shrubs grew fast, to 2 × 2 m, in effect forming a closed shrub canopy (Fig. 2). A standing crop of 3 t/ha dry matter of leaves and soft twigs (as browsed by sheep) was attained in the third year and has maintained static ever since. Shrub development was measured until 1966/67. The excellent shrub development made the area almost impenetrable to sheep; thus in effect taking the saltbush out of grazing altogether. In addition, the dense saltbush development reduced all ground vegetation. At the planting density we practiced, there was little to be grazed on the plot except to browse saltbush.

Shrub chemical composition and nutrient value in different seasons are shown in Table 2, taken from Fyaz and Benjamin (1958). This table indicates the high nutrient value of saltbush on the one hand, and the high ash content on the other. The salt content of the leaves undergoes annual rhythmical fluctuations, as shown by Lachover and Tadmor (1965). These authors have shown also that *Atriplex halimus* leaves contain some 10-11% oxalates in their dry matter, of which about 22% is soluble. These high salt and oxalate concentrations are probably a major cause of the low saltbush intake by sheep, which does not exceed 30-500 g/day in summer (Benjamin et al., 1959) when some dry grass stubble and free water were available around the shrubs.

The chemical composition patterns of *Atriplex halimus* are similar to those reported for other *Atriplex* species (Dixon, 1880; Beadle et al., 1957; Chatterton et al., 1971; Sharma et al., 1972). The overall mineral content of *Atriplex halimus* seems to be within the upper part of the range of reported concentrations.

**Secondary Production**

**Lamb Production from Grain Plots**

During Phase I of the experiment, lambing rates (lambs born per ewe in the flock) were 1.06 and 0.75 on the 0.3 and 0.6 ha/ewe stocking rates, respectively. Growth rates of lambs during the green season varied between 300 and 350 g per day, yielding a production of 30 kg lamb live weight per ewe and 100 kg/ha under the higher stocking rate, and 20 kg and 33 kg, respectively, under the lower rate. Grazing under the lower stocking rate was hardly noticeable in the fields (Fig. 3) and the sheep became very fat, which may have accounted for the relatively low fertility on these plots.

The parallel production of lamb and grain in three successive years of Phase II is shown in Table 3. The highest sustained stocking rate on wheat (i.e., 8-9 months of grazing each year) was 5 ewes/ha (0.2 ha/ewe) Fig. 4). On the heaviest stocking rate (0.05 ha/ewe) the vegetation was grazed out in less than 4 months, and this treatment was discontinued. Average yearly production on the medium stocking rates was about 70 to 80 kg/ha lamb live weight, which equals the best results of the legume pastures. The very high yields (138-197 kg/ha) on the 0.1 ha/ewe stocking rate show that if other pastures are available and wheat is used just

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**Table 2. Chemical composition (% dry matter) of fresh *Atriplex halimus* leaves.**

<table>
<thead>
<tr>
<th>Date of sampling</th>
<th>Protein</th>
<th>Fiber</th>
<th>Fat</th>
<th>Ether extract</th>
<th>Ash</th>
<th>Carotene ug/g</th>
</tr>
</thead>
<tbody>
<tr>
<td>June 1956</td>
<td>17.0</td>
<td>10.3</td>
<td>2.5</td>
<td>36.9</td>
<td>33.5</td>
<td>35</td>
</tr>
<tr>
<td>September 1956a</td>
<td>13.2</td>
<td>13.5</td>
<td>1.6</td>
<td>32.9</td>
<td>29.8</td>
<td>10</td>
</tr>
<tr>
<td>September 1956b</td>
<td>6.8</td>
<td>12.8</td>
<td>1.8</td>
<td>44.5</td>
<td>26.9</td>
<td>8</td>
</tr>
<tr>
<td>February 1957</td>
<td>15.5</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>24</td>
</tr>
</tbody>
</table>

*Dry leaves.*
during the lamb growing season, very high yields may indeed be reached. The drop off at the lowest stocking rate was a result of declined sheep fertility due to overfattening as well as to fewer sheep per area.

However, it should be noted that only in the good season of 1971/72, when ungrazed plots yielded 3.5 tons of grain per hectare, was there enough grain left to warrant harvesting the grazed plots, provided that the stocking rate was not higher than 0.2 ha/ewe. The combined value of lamb and grain did not exceed that of grain alone in any year.

The results seem to indicate that when grain is sown on fallow, even in a 250-mm rainfall area, grazing it before the harvest is not worthwhile unless the fertility of the sheep is better than that exhibited in the present work. This may be different in worse drought years, at very low stocking rates or if grazing is restricted to a short period during the early stages of the plant growth.

**Lamb Production from Legume Fields**

As explained in an earlier report (Tadmor et al., 1974), the aim of the first experimental phase was to arrive at an approximation of the carrying capacity of the area. The first two seasons were regarded as an adjustment period, starting with hoggets (yearlings). In the third year (1967) lambs were born in only two out of four plots. The suggested reason for this lack of fertility is discussed below.

A comparison of the results with those given by Tadmor et al. (1974) for unimproved native pastures indicates the increased primary productive capacity of improved pastures. At the 0.6 ha/ewe stocking rate the production per ewe and per unit area was 1.75 times that of the native pasture. The higher stocking rate resulted in a fourfold production per unit area over the light stocking rate. This large difference was, however, partly due to the reproductive failure on the 1.2 ha/ewe plot.

Of the four legume plots in 1967, reproduction was normal only in one. This plot differed from the others in botanical composition. Whereas all plots were dominated by barrel medic, this plot contained a considerable percentage of ryegrass in the relevant 2 years (1966/67). Various authors have shown that barrel medic under certain conditions may contain an oestrogenic factor (coumestrol) which may cause reproductive disorders (Adler and Trainin, 1960; Loper and Hanson, 1964; Weitzkin et al., 1968).

The lowered fertility was a product of 1966 breeding season, which was a drought year. In 1967, which was a good rainfall year, the plants were tested and oestrogenic activity was found. The same sheep showed normal fertility in 1967. The problem could not be followed up, as in subsequent years the number of legumes gradually diminished. For a review of this subject, see Moule et al. (1963).

The sheep which were brought in for experimental phase II were of mixed origin and previous history. Therefore, the first year (1968/69) must be regarded as a preparatory year. True treatment effects became apparent from the second year on.

The vegetation on the 0.1 ha/ewe plots was grazed out both in 1969 and 1970 in about 6 months; consequently, this plot showed poor rejuvenation from the overgrazing (Fig. 1, bottom). Therefore, grazing was discontinued. Figure 5 shows average relationships between stocking rate and several lamb production parameters.
Overall fertility was slightly lower than on the native pastures (Tadmor et al., 1974). This is partly due to the fact that the Awassi ewes included in the present work are less fertile than Mutton Merinos. It could also be a result of the unselected character of the sheep populations which were bought from various sources. There seemed to be a gradual rise of fertility with declining stocking rates. However, the regression of fertility on stocking rate was not statistically significant ($P > 0.10$). Body weights of ewes were higher on the lower stocking rates and the regression of fertility on body weight was highly significant. It may be assumed that the relationship found between stocking rate and fertility (Fig. 5) is a true one.

Daily weight gains during the green season were very high and similar to those described on natural pastures. It is interesting to note that the daily weight gains on legume pasture were not above weight gains on the native pasture. In both cases, during the growing season, there was good, palatable, nutritious feed in great surplus in all years.

The question of evaluating yield per ewe against yield per unit area was discussed in the previous report (Tadmor et al., 1974). The lamb weight yields per ewe were slightly higher on the legume plots in comparison with similar stocking rates on native pastures. There were, however, no differences in yield per hectare, due to the slightly lower ewe fertility in the legume plots. Another reason for relatively low average figures on the legume plots is the bias given by the low 1970 figures (one out of 3 years) as compared with the native pastures, in which that drought year was one out of 4 or 5 years compared.

It should be noted that ewes had to be withdrawn during autumn and early winter from legume plots which were stocked at rates of 0.3 ha/ewe and higher. A stocking rate of 0.6 ha/ewe, which barely supported year-round grazing on the native pasture, was undergrazed on the improved legume pasture or its subsequent vegetation. Because of the high primary production of the legumes and the resultant higher sustained stocking rates, potential secondary production from the legume pastures should have been high. Lamb production on the higher stocking rates reached 60 to 100 kg/ha in certain seasons. These high yields were obtained in the years when "legume pastures" were no longer legumes but grasses—"weeds." The results obtained indicate the high potential productivity of the legume pastures, due to the high soil fertility even in an arid environment.

**Sheep Performance on Saltbush Shrubs**

The few experiments reported on sheep grazing (or otherwise consuming) *Atriplex* all used either wethers or dry sheep. In the present experiment, breeding ewes were used for lamb production and this must be borne in mind when evaluating the results.

As can be seen from Table 4 and Figure 6, the performance of sheep kept on *Atriplex* plots was inferior to that of sheep kept on unimproved native pastures. Differences between the two pasture types were formed mainly under the higher stocking rates, indicating that the annual vegetation was insufficient to support the sheep (Table 4). The saltbush itself, which was only lightly grazed even under the heavier stocking rate, seems to have played at most a minor role in providing forage for the sheep.

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Stocking rate</th>
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<tbody>
<tr>
<td></td>
<td>Native pasture</td>
</tr>
<tr>
<td>Per ha</td>
<td>20</td>
</tr>
<tr>
<td>Per ewe</td>
<td>8.0</td>
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<table>
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<tr>
<th>Year</th>
<th>1965/66</th>
<th>1966/67</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of ewes</td>
<td>40</td>
<td>24</td>
</tr>
<tr>
<td>Lambs born per ewe in flock</td>
<td>0.53</td>
<td>0.48</td>
</tr>
<tr>
<td>Lambs born per lambing</td>
<td>1.06</td>
<td>1.75</td>
</tr>
<tr>
<td>Lamb mortality (%)</td>
<td>41</td>
<td>10</td>
</tr>
<tr>
<td>Lamb birth weights (kg)</td>
<td>4.0</td>
<td>4.3</td>
</tr>
<tr>
<td>Lamb daily weight gain (g) in green season</td>
<td>200</td>
<td>275</td>
</tr>
</tbody>
</table>
and of the fact that the sheep did not compensate for this deficiency by increasing saltbush intake sufficiently.

Wool yields were much lower in sheep kept on the saltbush as compared with those on native pastures (Table 6), indicating a true nutritive deficiency in the saltbush plots. Under the saltbush there was also a clear stocking rate effect.

Wilson et al. (1969) have reported that an *Atriplex vesicaria* community completely supported Merino wethers at a stocking rate of 1.6 ha/sheep. The intake of saltbush leaves was increased by the wethers from less than 10% of the diet during the spring pasture growing season to about 80% in early winter when the annual vegetation had been grazed down. No data on density of *A. vesicaria* were given by these authors.

A situation which seems to resemble our results was reported by Leigh et al. (1968) with a *Kochia* community. Here the *Kochia* contributed only 2 and 7% of the autumn intake of wethers under stocking rates of 1.06 and 0.53 ha/head, respectively. The addition of *Kochia* to the pasture had no effect on wool production.

It is interesting to note that body weights were slightly higher with the *Kochia* supplement under the light stocking rate and lower with the *Kochia* supplement under the heavier stocking rate, in comparison with unsupplemented grasses. This may suggest that the supplement, though small, may be valuable as a protein supplement and perhaps also for vitamins and other minor factors when energy supply is sufficient. The same may apply also to the *Atriplex halimus* used in the present work. Eyal and Benjamin (1958) and Wilson (1966a) have shown that sheep which are fed on saltbush alone consume daily about 560 g dry matter of leaves of different species showing very similar chemical composition (17-20% crude protein, 10% fiber and 30-33% ash). These amounts were sufficient for 40- to 45-kg sheep to maintain their weight or even show some gain. However, it is doubtful whether this gain is indicative of the energy balance of the sheep, as sheep eating saltbush increase their water intake considerably (Wilson, 1966b) and the actual weight may be merely a product of changes in body water content.

Why the sheep in our experiments did not consume as much *Atriplex* as would be expected from the metabolism cage experiment (Eyal and Benjamin, 1958), is hard to tell. It seems that the salt or oxalate contents per se are not the whole answer, as other saltbush species with similar contents of these chemicals were readily eaten by sheep (Wilson 1966a; Wilson et al., 1969). Seasonal changes in the preference for saltbush plants by sheep were found by Forti (personal communications) in a 3-year experiment at Migda. It may be concluded that for an evaluation of the fodder value of *Atriplex halimus*, and other saltbush species, experiments have to be carried out applying different stocking rates with a range of saltbush plant densities much lower than the one used in the present experiment.

In conclusion, it seems that the high nutrient content of saltbush leaves might make saltbush a valuable addition to the grazing of any annual pasture, provided saltbush does not constitute more than a small—yet to be defined—portion of the pasture. Another potential use of the high-yielding saltbush could be as drought reserve. Saltbush paddocks allow the accumulation of about 3 ton/ha standing edible dry matter, which is stable over the seasons. Although of low palatability and not suitable as a sole feed, this is more per unit area than the fast-disintegrating standing hay or the herbaceous annuals. This aspect merits further investigation.

**Literature Cited**

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