Reproductive performance from feeding tree fodder to ewes grazing drought pasture during mating

E.L. MCWILLIAM[1], T.N.BARRY[1], N. LOPEZ-VILLALOBOS[1], P.N. CAMERON[2], P.D. KEMP[3] and D.J. CAMERON[2]
[1]*Institute of Veterinary, Animal and Biomedical Sciences, Massey University, Palmerston North*
[2]*Greater Wellington Regional Council, 34 Chapel Street, Masterton*
[3]*Institute of Natural Resources, Massey University, Palmerston North*
A.E.McWilliam@xtra.co.nz

Abstract
Grazing experiments were conducted in late summer/autumn of 2001 and 2002, at Massey University's Riverside Farm, Masterton, to determine the effects of poplar and willow supplementation during drought on ewe reproductive rate, when grazing low quality drought pasture. Ewes (55–57 kg live weight) grazed drought pasture in a rotational grazing system, with pre- and post-grazing pasture masses of 1040–940 and 530–550 kg dry matter (DM)/ha. In 2001, poplar trimmings were offered at the rate of 1.50 and 0.75 kg/ewe/day (fresh), to the high and low treatment groups, respectively (n=100 ewes/group). In 2002, 1.40 kg/head/day (fresh) willow and poplar trimmings were offered to the willow or poplar treatment groups (n=95 ewes/group). The poplar trimmings offered to ewes in the 2002 experiment were severely contaminated by poplar leaf rust.

Poplar and willow consumed was higher in mean nitrogen content and organic matter digestibility, and lower in average neutral detergent fibre content, than the low quality drought pasture consumed by the control ewes. Control ewes lost live weight (82 and 104 g/day) during the mating periods in both experiments. Supplementation with poplar and willow slightly reduced live weight loss and loss of body condition, however these differences disappeared in the post-treatment period.

Reproductive rate was low in the control groups of ewes (121 & 131 lambs born/ 100 ewes mated). In the 2001 experiment, poplar supplementation increased ewe reproductive rate by 20% units ($p<0.05$) and 34% units ($p<0.001$) for the low and high treatment groups, respectively, as compared to the control group. In the 2002 experiment, willow supplementation increased reproductive rate by 15% units ($p=0.01$) compared to the control group, with the advantage increasing to 21% units ($p<0.05$) at docking. Poplar supplementation had no effect on reproductive rate in the 2002 experiment. Increases in reproductive rate in supplemented ewes were mainly due to increases in the number of multiple-births.

It was concluded that poplar and willow trimmings are beneficial supplements for increasing the reproductive rate of ewes grazing drought pasture during the pre-mating and mating periods, providing the tree fodder is not contaminated with rust. Poplar and willow supplementation increased intakes of DM, metabolisable energy (ME) and crude protein, and increased protein intake as a proportion of ME intake during the mating period in the 2001 experiment. All of these factors could be involved in explaining the increased reproductive performance of poplar and willow-supplemented ewes.

Keywords: Drought feeding; Poplar (*Populus* sp.) supplementation; Reproduction; Willow (*Salix* sp.) supplementation

Introduction

Drought and drought planning are an integral part of farming in the East Coast regions of New Zealand, including Gisborne, Hawke's Bay, Wairarapa, Marlborough, Canterbury, and North Otago. Intensely hot, dry conditions during the summer and early autumn are common in these regions, with severe droughts occurring every 7–10 years. Droughts cause large losses in livestock productivity on pastoral farms, resulting in large losses in farm revenue. Ward (1999) estimated that the farm gate cost of the 1997 and 1998 droughts totalled $NZ 800 million for the effects not only on the 1997/98 financial year, but also losses in 1999 and 2000 due to the follow-on effects of drought.

Drought in the summer/autumn severely affects sheep production systems, as low soil moisture levels significantly reduce pasture growth and quality, thus limiting the feed available for grazing ewes during the pre-mating and mating periods. Feeding ewes at a level below maintenance results in loss of live weight and body condition and, during mating, severely reduces ovulation rate and subsequent lambing percentage (Rattray *et al.* 1981, Rattray *et al.* 1983 a, b, Smith & Knight 1998).

Farmer experience has shown that managing willow and poplar trees originally planted for soil conservation purposes, as a source of fodder for livestock, is one method of rectifying summer feed shortages. However, little is known about the effects of this practice on livestock production. Thus, grazing trials were conducted in the Masterton area in the summer and autumn of 2001 and 2002 to determine the effects of supplementation with willow and poplar trimmings during mating on the reproductive rate of ewes grazing drought pasture.

Methods

In the summer and autumn of 2001 and 2002, grazing trials involving mixed-age Romney-based ewes, with mean initial live weights of 57 ± 0.7 kg and 55 ± 0.3 kg, respectively, were conducted at Massey University's Riverside Farm, in Masterton.

Poplar supplementation was carried out over 71 days in the 2001 experiment. In the 2002 experiment, poplar and willow trimmings were fed to separate groups of ewes for 80 days. Greater Wellington Regional Council's Akura Nursery, near Masterton, supplied the poplar and willow trimmings.

Both experiments involved ewes grazing simulated drought pasture, with poplar and willow material, with a stem diameter of less than 15 mm, offered daily as supplementary feed. In each year, ewes were randomly allocated to three treatment groups. In 2001, poplar trimmings (clone Veronese) were offered at the rate of 1.50 kg/head/day (fresh) and 0.75 kg/head/day (fresh) to the high and low treatment groups, respectively (n=100 ewes/group). In 2002, 1.40 kg/head/day (fresh) willow (clones Tangoio and Moutere) and poplar (clones Veronese, Toa, Tasman, Weraiti, and Otahoua) trimmings were offered to the willow or poplar treatment groups (n=95 ewes/group). In the 2002 experiment, the poplar trimmings offered were severely contaminated by poplar leaf rust (caused by *Melampsora larici-populina*), due to wet and humid conditions during the late summer and early autumn. This did not occur in the 2001 experiment. In both years, control groups of ewes grazed similar drought pasture but were not offered tree trimmings. All groups were offered approximately 0.70 kg dry matter (DM)/head/day of dry, low quality pasture in a 7–14 day rotational-grazing system in both years.

In the 2001 and 2002 experiments, mating occurred over a 6-week period. In 2001, poplar supplementation ceased after 27 days of mating, due to early autumn leaf fall. In 2002, the supplementation period included the 6-week mating period.

Pre- and post-grazing herbage mass was determined immediately before and after grazing each 7–14 day break, by cutting eight random quadrants per treatment group per break, to ground level. Pasture diet selected samples were collected from each break, by hand-plucking from exclusion cages immediately following grazing. Poplar and willow fodder offered was weighed daily and samples were collected twice weekly to determine the DM content of tree material offered. Tree fodder residual was collected and weighed after each break and samples taken to determine DM content. Thus, the total amount of poplar or willow (kg DM) consumed was calculated for each break. The diameter of poplar and willow stems eaten was determined at the end of grazing each break, by collecting 75 stems per treatment group and measuring the diameter eaten with electronic callipers (Mitutoyo Corp., Japan). Samples of poplar and willow diet selected were also pruned daily from the willow and poplar fodder on offer, at a diameter that was consistent with the diameter consumed by the ewes (3–5 mm for willow and 5–7 mm for poplar) and pooled at -20° C for each break.

Ewes were weighed fortnightly using electronic scales (Tru-test, New Zealand) during the period of tree fodder supplementation and body condition, scored from

1 to 5, assessed monthly. After mating, the ewes were managed as one group and weighed and scored for body condition monthly, until weaning in late November. The number of lambs per group at ultrasound scanning (June), lambing, docking and weaning was recorded.

Poplar, willow and pasture samples of diet selected were stored at -20°C, freeze-dried and ground to pass through a 1 mm diameter sieve. Total nitrogen (N) concentration was determined using the Kjeldahl method. Neutral detergent fibre (NDF) concentration was determined by the detergent procedures of Robertson and Van Soest (1981) and Van Soest et al. (1991), with alpha amylase (BDH, Poole, UK) being added during NDF extraction. *In vitro* Organic Matter Digestibility (OMD) was determined by the enzymatic method of Roughan and Holland (1977), using separate standard curves prepared from *in vivo* values for forages and from tree fodder fed to sheep.

Changes in ewe live weight and body condition were analysed using PROC MIXED of SAS (2001) with a linear model that considered the effect of treatment. Differences

Table 1a. Pasture mass, chemical composition of pasture diet selected, live weight change and reproductive rate in ewes (100/group) supplemented with high or low amounts of poplar, or no poplar (control), for 71 days, including the mating period, when grazing low quality drought pasture in summer/autumn 2001 (mean values with standard errors).

		Poplar Supplementation	
	Control	**Low rate**	**High rate**
Poplar offered:			
(kg fresh/ewe/day)	0	0.75	1.50
Pasture mass: (n=8)			
(kg DM/ha)			
Pre-grazing	1034 ± 94.3	1044 ± 93.7	1042 ± 101.7
Post-grazing	533 ± 52.4	547 ± 39.9	512 ± 49.3
Chemical composition of pasture diet selected: (n=8)			
Total N (g/kg DM)	17.0 ± 1.9	18.4 ± 1.5	18.0 ± 1.8
NDF (g/kg DM)	623.2 ± 10.6	621.0 ± 15.0	623.2 ± 12.5
OMD	0.537 ± 0.007	0.549 ± 0.015	0.538 ± 0.009
Live weight and body-condition-score change:			
Live weight (g/day)	-82[a] ± 5.3	-71[ab] ± 5.3	-67[b] ± 5.2
Body condition score (units)	-1.31[a] ± 0.046	-1.27[a] ± 0.046	-0.78[b] ± 0.046
Reproductive data:			
Conception rate[1]	92.9[b] ± 1.89	95.8[ab] ± 1.92	100[a] ± 1.89
Scanning[2]	122[b] ± 5.7	147[a] ± 5.8	163[a] ± 5.7
Lambing[2]	121[b] ± 5.8	141[a] ± 5.9	155[a] ± 5.8
Docking[2]	97[b] ± 6.4	113[ab] ± 6.5	127[a] ± 6.4
Weaning[2]	96[b] ± 6.4	113[ab] ± 6.5	125[a] ± 6.4

[1] Ewes pregnant per 100 ewes mated.
[2] Lambs per 100 ewes mated.
[ab] Means within rows with different superscripts differ significantly (P<0.05).

in pregnancy rate between treatments were tested using PROC CATMOD of SAS (2001). Least-squares means for reproductive rate at scanning, lambing, docking and weaning were obtained for each treatment using PROC MIXED of SAS (2001). Reproductive performance was expressed as number of lambs born as a proportion of the number of ewes mated.

Results

Mean pre-grazing pasture masses for the three groups were 1040 and 940 kg DM/ ha and mean post-grazing residuals were 530 and 550 kg DM/ha (Table 1), respectively, for the 2001 and 2002 experiments, with no difference between the three groups in each year. Pasture consumed during the 2002 experiment, as compared to the 2001 experiment, was higher in total N concentration (24.9 ± 1.1 vs 17.8 ± 1.0 g/kg DM) and OMD (0.563 ± 0.009 vs 0.542 ± 0.006) and lower in NDF (570.6 ± 9.7 vs 622.5 ± 7.1 g/kg DM), with no difference between the three groups in each year (Tables 1a & 1b).

Table 1b. Pasture mass, chemical composition of pasture diet selected, live weight change and reproductive rate in ewes (95/group) supplemented with willow, poplar or pasture only (control), for 80 days, including the mating period, when grazing low quality drought pasture in summer/autumn 2002 (mean values with standard errors).

		----- Supplementation -----	
	Control	**Poplar**	**Willow**
Poplar or willow offered:			
(kg fresh/ewe/day)	0	1.40	1.40
Pasture mass: (n=10)			
(kg DM/ha)			
Pre-grazing	909 ± 86.9	959 ± 72.2	954 ± 61.0
Post-grazing	420 ± 45.4	497 ± 47.6	450 ± 34.7
Chemical composition of pasture diet selected: (n=5)			
Total N (g/kg DM)	24.5 ± 2.03	25.2 ± 1.78	25.1 ± 2.55
NDF (g/kg DM)	572.3 ± 18.36	567.8 ± 15.32	571.6 ± 20.51
OMD	0.549 ± 0.014	0.572 ± 0.013	0.569 ± 0.020
Live weight and body-condition-score change:			
Live weight (g/day)	-103[a] ± 4.3	-95[ab] ± 4.3	- 86[b] ± 4.2
Body condition score (units)	-0.69 ± 0.051	-0.59 ± 0.051	-0.60 ± 0.050
Reproductive data:			
Conception rate[1]	91.4 ± 2.91	87.0 ± 3.51	91.4 ± 2.91
Scanning[2]	133[ab] ± 6.8	127[b] ± 6.9	148[a] ± 6.8
Lambing[2]	131[ab] ± 6.9	122[b] ± 6.9	148[a] ± 6.9
Docking[2]	107[b] ± 7.4	97[b] ± 7.4	128[a] ± 7.4
Weaning[2]	106[ab] ± 7.4	97[b] ± 7.4	126[a] ± 7.4

[1] Ewes pregnant per 100 ewes mated.
[2] Lambs per 100 ewes mated.
[ab] Means within rows with different superscripts differ significantly ($P<0.05$).

In both experiments, the tree fodder consumed was higher in mean N concentration and OMD and lower in average NDF than the pasture consumed. In 2001, the poplar consumed had a N concentration of 28.4 ± 1.5 g/kg DM, an OMD of 0.657 ± 0.008, and a NDF concentration of 389.9 ± 14.1 g/kg DM. In 2002, poplar and willow had N concentrations of 27.4 ± 0.9 and 26.3 ± 0.7 g/kg DM, OMD of 0.624 ± 0.014 and 0.692 ± 0.014, and NDF concentrations of 404.4 ± 8.6 and 381.3 ± 6.0 g/kg DM, respectively.

The DM content of poplar offered in the 2001 (P<0.001) and 2002 (P=0.0641) experiments, and willow offered in 2002 (P<0.001), increased significantly over the supplementation period (Figures 1a & 1b). The poplar offered had similar mean values of 343 and 348g/kg for 2001 and 2002, respectively, while the mean DM content of willow was slightly higher at 387g/kg.

Figure 1a. Change in the dry matter content of poplar offered during the 2001 experiment.

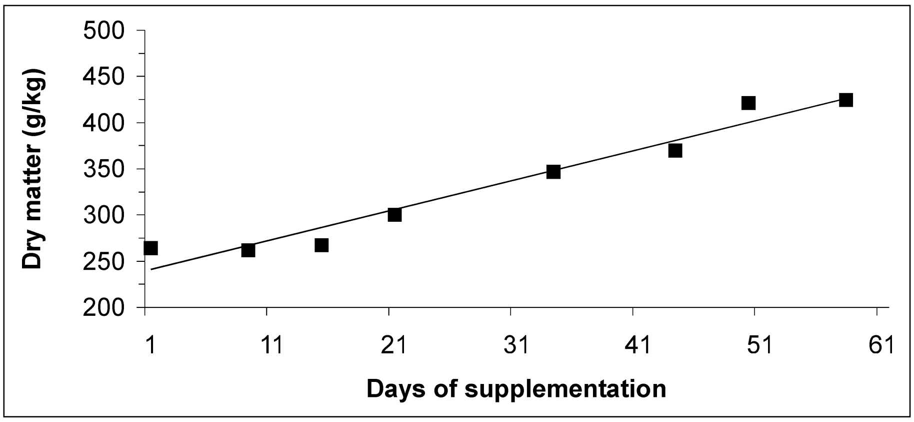
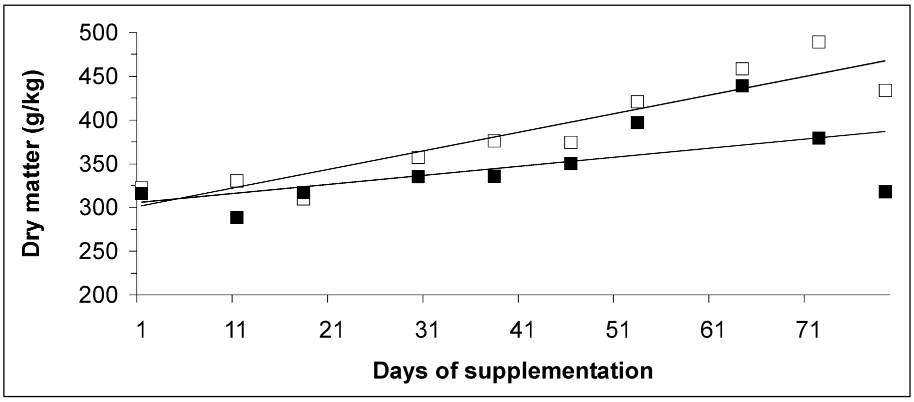


Figure 1b. Change in the dry matter content of willow and poplar offered during the 2002 experiment. □ Willow; ■ Poplar



Diameter (mm) of the poplar stem eaten increased significantly ($p<0.01$) over the supplementation period for both poplar supplementation groups in the 2001 ($P<0.01$) and 2002 ($P<0.05$) experiments (Figures 2a & 2b). Mean diameters of poplar stem consumed were 7.5 mm and 7.4 mm for the low and high treatments in 2001, and 6.5 mm in 2002. Willow trimmings consumed by ewes in the 2002 experiment showed a slight reduction in the diameter of stem eaten with time ($P<0.05$), with a mean diameter of 3.7mm (Figure 2b). In the 2001 experiment, the amount of poplar consumed increased significantly ($P<0.01$) over the experimental period for both the low and high treatment groups with mean values of 0.17 kg and 0.33 kg DM/head/day, respectively. In the 2002 experiment, ewes consumed 0.25 kg DM/head/day of willow trimmings and 0.27 kg DM/head/day of poplar trimmings, with no significant trend over time.

Figure 2a. Change in the diameter of poplar stem consumed during the 2001 experiment.
n=75 determinations per data point. ▲ High; ■ Low

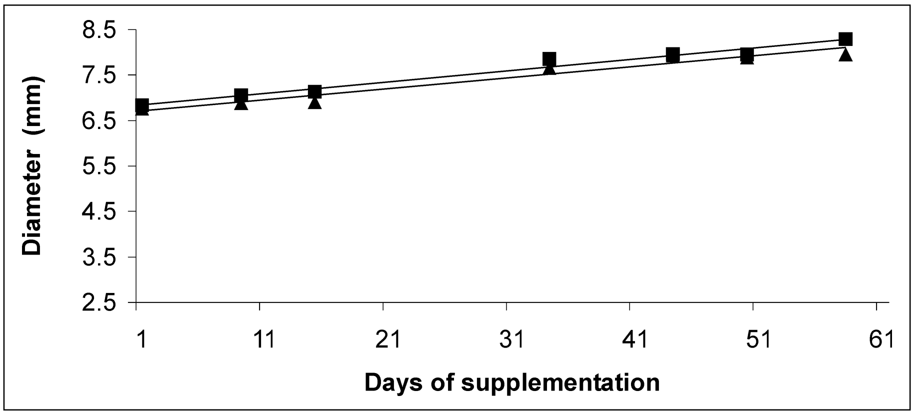
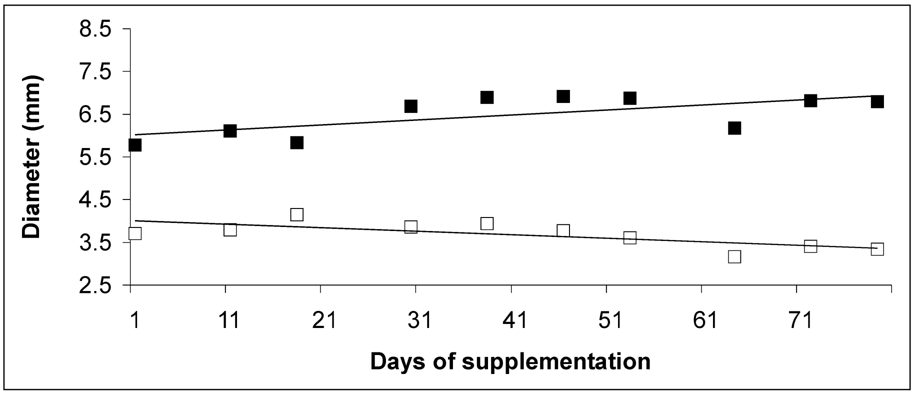


Figure 2b. Change in the diameter of willow and poplar stem consumed during the 2002 experiment. n=75 determinations per data point. □ Willow; ■ Poplar.



In both experiments, all groups of ewes lost live weight and body condition during the supplementation period (Tables 1a & 1b), as would happen in a severe drought. In 2001, the high rate of poplar supplementation reduced live weight loss by 15g/ day (P<0.05) and body condition loss by 0.53 units (P<0.001), as compared to the control group. The low rate of poplar supplementation reduced live weight and body condition loss by a small, but insignificant amount. In 2002, willow supplementation reduced live weight loss by 17g/day (p<0.01) and body condition loss by a small but insignificant amount; however poplar supplementation showed no effects on live weight or body condition loss (Table 1b).

Ultrasound pregnancy scanning showed increases in reproductive rate of 41% units (P<0.001) for the high and 25% units (P<0.01) for the low rate of poplar supplementation, compared to the control group, in the 2001 experiment (Table 1a). At lambing, the advantage in reproductive rate decreased to 34% units (P<0.001) for the high and 20% units (P<0.05) for the low treatment groups (Table 1a). The increase in reproductive rate in ewes supplemented with poplar, in the 2001 experiment, was due to increases in conception rate (Table 1a) and the number of multiple-births.

In the 2002 experiment, ultrasound pregnancy scanning showed increases in reproductive rate of 15% units (P=0.10) for the willow supplementation group, compared to the control group (Table 1b). This advantage increased to 17% units (P=0.09) at lambing, 21% units (P<0.05) at docking, and 20% units (P=0.06) at weaning (Table 1b). Poplar supplementation had no effect on reproductive rate in the 2002 experiment (Table 1b). The increase in reproductive rate, in ewes supplemented with willow trimmings, was due to increases in the number of multiple-births. There was no effect of willow or poplar supplementation on conception rate in 2002 (Table 1b).

Discussion

The objective of the experiments in 2001 and 2002 was to determine reproduction responses to the supplementation of ewes with poplar and willow trimmings, during mating, when grazing low quality drought pasture under dry East Coast conditions. The studies showed that supplementation with poplar or willow trimmings markedly increased reproductive performance and slightly reduced the rate of live weight loss in grazing ewes. The 2002 experiment also showed that poplar trimmings that are severely infected with poplar leaf rust had no effect on reproductive rate and liveweight when fed to ewes during mating.

The increases in reproductive rate in ewes supplemented with poplar and willow were due to increases in both conception rate and fecundity, with a higher proportion of pregnant ewes and a higher proportion of multiple pregnancies in the supplemented groups. One mechanism to explain the increase in reproductive rate and reduction in live weight loss, in the ewes supplemented with poplar and willow fodder, is an increase in DM and metabolisable energy (ME) consumed during the experiments (i.e. flushing effect). In 2001, the control, low and high groups were estimated to consume 0.67, 0.87 and 1.03 kg total DM/head/day and 5.2, 7.1 and 8.6 MJ total ME/ewe/day, respectively (Table 2a). In 2002, the control, poplar and willow groups were estimated to consume 0.59, 0.83 and 0.86 kg total DM/head/day and 4.7, 6.9 and 7.3 MJ total ME/ewe/day, respectively (Table 2b). Scientific evidence and farmer experience have shown that increasing nutritional intake through supplementation in the pre-mating and mating periods increases ewe live weight and ovulation rate, which is reflected in increases in lambing percentage (Rattray *et al.* 1981; Rattray *et al.* 1983 a, b; Smith *et al.* 1983; Smith 1985; Smith & Knight 1998).

Protein is also a critical component of the reproductive response of ewes to supplementary feeding. Studies have found significant responses to increased protein

Table 2a. The effect of supplementation with poplar trimmings, for 71 days during late summer/autumn 2001, including mating, on ewes grazing drought pastures, on calculated dry matter intake (kg DM/ewe/day), calculated metabolisable energy (ME) intake (MJ ME/ewe/day) and calculated crude protein (CP) intake (g/ewe/day) (mean values with standard errors).

		Poplar Supplementation	
	Control	**Low rate**	**High rate**
DM Intake*:			
Pasture[1]	0.67 ± 0.138	0.69 ± 0.147	0.70 ± 0.148
Poplar	0	0.18 ± 0.021	0.33 ± 0.036
Total	0.67 ± 0.138	0.87 ± 0.135	1.03 ± 0.128
ME Intake[2]:			
Pasture	5.2 ± 1.07	5.3 ± 1.14	5.4 ± 1.15
Poplar	0	1.8 ± 0.21	3.2 ± 0.37
Total	5.2 ± 1.07	7.1 ± 1.03	8.6 ± 0.96
CP Intake[3]:			
Pre-mating period			
Pasture	80.5 ± 10.82	88.5 ± 7.38	89.1 ± 10.16
Poplar	0	23.2 ± 3.04	44.7 ± 5.88
Total	80.5 ± 10.82	111.7 ± 4.99	133.8 ± 4.92
Proportion of intake from poplar	0	0.21	0.33
Mating period			
Pasture	61.5 ± 10.58	70.0 ± 8.82	68.6 ± 10.69
Poplar	0	34.8 ± 2.03	61.9 ± 3.22
Total	61.5 ± 10.58	104.8 ± 6.93	130.5 ± 7.64
Proportion of intake from poplar	0	0.33	0.47
g CP Intake / MJ ME Intake:			
Pre-mating	15.5 ± 2.08	15.8 ± 0.71	15.5 ± 0.57
Mating	11.8 ± 2.04	14.8 ± 0.98	15.1 ± 0.89

[1] Estimated from pasture mass measurements before and after grazing.
[2] DM intake * mean ME concentration in MJ/kg DM.
[3] DM intake * CP concentration

Table 2b. The effect of supplementation with poplar and willow trimmings, for 80 days during late summer/autumn 2002, including mating, on ewes grazing drought pastures, on calculated dry matter intake (kg DM/ewe/day), calculated metabolisable energy (ME) intake (MJ ME/ewe/day) and calculated crude protein (CP) intake (g/ewe/day) (mean values with standard errors).

		----- Supplementation -----	
	Control	**Poplar**	**Willow**
DM intake:			
Pasture[1]	0.59 ± 0.06	0.56 ± 0.070	0.61 ± 0.059
Willow/Poplar	0	0.27 ± 0.017	0.25 ± 0.013
Total	0.59 ± 0.06	0.83 ± 0.071	0.86 ± 0.063
ME intake[2]:			
Pasture	4.7 ± 0.44	4.4 ± 0.56	4.8 ± 0.46
Willow/Poplar	0	2.5 ± 0.13	2.5 ± 0.16
Total	4.7 ± 0.44	6.9 ± 0.57	7.3 ± 0.51
CP intake[3]:			
Pasture	90.5 ± 7.49	88.1 ± 6.24	95.7 ± 9.72
Willow/Poplar	0	45.8 ± 2.42	41.0 ± 2.39
Total	90.5 ± 7.49	133.9 ± 3.56	136.7 ± 5.69
g CP intake / MJ ME intake:	19.2 ± 1.06	19.4 ± 0.52	19.2 ± 0.80

1 Estimated from pasture mass measurements before and after grazing.
2 DM intake * mean ME concentration in MJ/kg DM.
3 DM intake * CP concentration

intakes of feeds that contain low and moderate energy levels (Smith 1985). Smith (1985) found a threshold intake level of 125 g protein/ewe/day necessary to achieve an increase in ovulation rate, with marked increases at levels above 125 g/ewe/day. In both the 2001 and 2002 experiments, the calculated crude protein (CP) intakes of the control ewes were well below this figure, while the calculated crude protein intakes of the poplar and willow-supplemented ewes approached or exceeded this figure (Tables 2a & 2b). In the 2001 experiment, calculated CP intake (g/ewe/day) as a proportion of ME intake (MJ/ewe/day) was similar for the three groups during the flushing period. However, during the mating period, ewes supplemented with poplar trimmings had a much greater proportional increase in CP intake than in ME intake due to the increase in the amount of poplar consumed over time. The 2002 experiment did not show a difference in the intake of CP as a proportion of ME intake between the pre-mating and mating periods, as the amount of poplar and willow eaten was fairly constant over the supplementation period. The increase in ME and CP intakes, during the flushing and mating periods, and the increase in protein intake as a proportion of ME intake, during the mating period, could all be involved in explaining the increased reproductive performance of poplar and willow-supplemented ewes.

The increase in reproductive rate from tree fodder supplementation was much greater than the difference in live weight change between the groups. Similar findings by Smith *et al.* (1983) show significant level of feeding effects on ewe ovulation rate additional to those associated with live weight change. They concluded that ovulation rate was a more sensitive indicator of nutritional changes than live weight, because response times for live weight changes are too slow to correlate with the very rapid changes that occur in the reproductive mechanisms controlling ovulation rate (Smith *et al.* 1983). The greater increases in reproductive rate relative to live weight change and DM, ME and CP intakes, leads the authors to conclude that the flushing effect of poplar and willow supplementation may not account for all of the increase in reproductive rate found in the present experiments.

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