# The Effect of Poplar (*Populus spp.*) and Willow (*Salix spp.*) Supplementation on the Reproductive Performance of Ewes Grazing Low Quality Drought Pasture During Mating

A thesis in partial fulfilment of the requirements for the degree of DOCTOR OF PHILOSOPHY in Animal Science in the Institute of Veterinary Animal and Biomedical Science, Massey University

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# CERTIFICATE OF REGULATORY COMPLIANCE

This is to certify that the research carried out in the Doctoral Thesis entitled: "The Effect of Poplar (*Populus*) and Willow (*Salix*) Supplementation on the Reproductive Performance of Ewes Grazing Low Quality Drought Pasture During Mating", in the Institute of Veterinary, Animal and Biomedical Sciences at Massey University, New Zealand:

(a) is the original work of the candidate, except as indicated by appropriate attribution in the text and/or in the acknowledgements;

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(c) all the ethical requirements applicable to this study have been complied with as required by Massey University, other organizations and/or committees that had a particular association with this study, and relevant legislation.

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## CANDIDATE'S DECLARATION

This is to certify that the research carried out for my Doctoral thesis entitled "The Effect of Poplar (*Populus*) and Willow (*Salix*) Supplementation on the Reproductive Performance of Ewes Grazing Low Quality Drought Pasture During Mating" in the Institute of Veterinary, Animal and Biomedical Sciences, Massey University, Turitea Campus, New Zealand is my own work and that the thesis material has not been used in part or in whole for any other qualification.

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## SUPERVISOR'S DECLARATION

This is to certify that the research carried out for the Doctoral thesis entitled "The Effect of Poplar (*Populus*) and Willow (*Salix*) Supplementation on the Reproductive Performance of Ewes Grazing Low Quality Drought Pasture During Mating" was done by Eileen L. McWilliam in the Institute of Veterinary, Animal and Biomedical Sciences, Massey University, Turitea Campus, New Zealand. The thesis material has not been used in part or in whole for any other qualification, and I confirm that the candidate has pursued the course of study in accordance with the requirements of the Massey University regulations.

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# ABSTRACT

A series of grazing experiments was conducted, in the summer/autumn of 2001, 2002 and 2003, to investigate the effects of poplar (*Populus spp.*) and/or willow (*Salix spp.*) supplementation, during mating, on ewe production and reproduction when grazing drought pasture. Each experiment involved a rotational grazing system with 300 mixed-age Romney ewes, divided into three groups of 100 ewes each. In each year, all ewes were offered low quality simulated drought pasture, containing more than 60% dead matter, at an allowance sufficient to provide a potential desired intake of 0.70 kg dry matter (DM)/day, for periods of 9 to12 weeks, including two mating cycles. Mean pre-and post-grazing pasture masses averaged over the three years were 1100 and 600 kg DM/ha. The pasture consumed in all years was typical of pasture available to grazing livestock in a drought; it was high in neutral detergent fibre (NDF; approximately 600 g/kg DM), low in organic matter digestibility (OMD; approximately 0.52) and metabolisable energy (ME; approximately 7.5 MJ/kg DM) and contained approximately 20 g nitrogen (N)/kg DM. The supplementary poplar and willow diets were always superior to drought pasture consumed by the ewes, being higher in OMD (approximately 0.67), ME (approximately 10 MJ/kg DM) and total N (approximately 26 g/kg DM) and lower in NDF (approximately 383 g/kg DM). Tree fodder diets also contained substantial concentrations of the secondary compounds condensed tannin (CT; range 7 to 52 g/kg DM), salicin (approximately 2 g/kg DM) and other phenolic glycosides (approximately 21g/kg DM), with willow (27 to 52 g/kg DM) containing greater concentrations of CT compared with poplar (7 to 19 g/kg DM). Mean diameter of the tree fodder stem consumed during the series of experiments was approximately 7 mm for poplar and 4 mm for willow with the diameter increasing over the experimental periods in four cases out of five ($P<0.05$). After the supplementation period, the three groups were joined together and grazed on perennial ryegrass/white clover pasture until the conclusion of each experiment at weaning. In all years, the effect of poplar and/or willow supplementation on ewe live weight (LW) and body condition score (BCS) change; the proportion of lambs (reproductive rate) at pregnancy scanning, lambing, docking and weaning; and wool production and staple length from ewe fleeces with approximately 11 months growth, were measured.

Experiment 1 was designed to determine how much poplar fodder needed to be fed to increase ewe production and reproduction over a 71-day supplementation period. The experiment involved a high supplementation group, offered 1.5 kg fresh poplar/ewe/day; a low supplementation group, offered 0.75 kg fresh poplar/ewe/day; and a control group that was offered no tree fodder. Ewes in the high and low treatments lost less LW (-67 and -71 vs. -82 g/day; $P<0.05$) and BCS (-0.78 and -1.27 vs. -1.31 units; $P<0.05$) compared with unsupplemented ewes. Reproductive rate was relatively low in the control group (121 lambs born/100 ewes mated), with poplar supplementation increasing ewe reproductive rate by approximately 20% units ($P<0.05$) and 30% units ($P<0.001$) for the low and high treatment groups, respectively, at scanning, lambing, docking and weaning. The increase in reproductive rate in supplemented ewes was due to increases in both conception rate (number of ewes pregnant/100 ewes mated) and fecundity (number of lambs born/100 ewes mated).

Experiment 2 was designed to determine if production and reproduction varied between ewes fed poplar versus willow at the same rate of supplementation, 1.4 kg fresh forage/ewe/day, for 87 days. Again, reproductive rate was relatively low in the control group (133 lambs born/100 ewes mated), with willow supplementation reducing LW loss (-86 g/day vs. -103 g/day; $P<0.01$) and increasing reproductive rate by 15%, 17% 21% and 20% units at ultrasound scanning ($P=0.097$), lambing ($P=0.087$), docking ($P<0.05$) and weaning ($P=0.058$), respectively. The increase in reproductive rate was due to an increase in fecundity; supplementation did not affect conception rate in this experiment. Unlike the previous experiment, poplar supplementation showed no effect on reproductive rate, despite the increase in DM intake and the apparent reduction in LW loss of 9 g/day ($P=0.11$). It is likely that severe contamination of the poplar fodder with *Melampsora larici-populina*, or poplar leaf rust, confounded the results.

Building on the results of the first two grazing trials, the next step was to determine the period (days) of tree fodder supplementation necessary to achieve a response in reproductive rate. Experiment 3 involved ewes fed 1.3 kg fresh willow/ewe/day for a 'long' period, 63 days including 6 weeks of mating, and a 'short' period, 31 days including 3 weeks of mating. The mating period commenced on the same day for all groups and lasted for 6 weeks. Willow supplementation for 63 days reduced ewe LW

loss (-96 g/day vs. -147 g/day; P<0.05) and BCS (-0.79 VS. -1.09; P<0.05) loss, compared with unsupplemented ewes; however, it did not increase reproductive rate at scanning and lambing. The lack of response in willow-supplemented ewes was likely to be due to toxic concentrations of zearalenone (1.5 mg/kg DM), an oestrogenic mycotoxin, in the drought pasture during mating, which confounded the results by negating any potential benefits due to increased nutrient intakes. Willow supplementation for 63 days did increase reproductive rate at weaning by 13% units, due to a 9% unit (P<0.05) reduction in post-natal lamb mortality, from 17.1 to 8.4%. Supplementation for 31 days did not appear to influence ewe reproduction and production parameters. Overall, the rate of LW loss was greater in Experiment 3 compared with the first two experiments.

Seven indoor *in vivo* digestibility experiments were conducted at the following times; early April 2001 (poplar), February, March and April 2002 (all poplar), and December, March and April 2003 (all willow). Each 14-day trial involved 6 male cryptorchid lambs, individually fed in metabolism cages. The experiments showed that the digestibility of poplar and willow tree fodder declined from late spring to autumn (P<0.05), but that the decline was much smaller than the decline in digestibility of grass-based pastures in New Zealand over the same time period. The experiments also showed that mean ME and digestibilities were generally higher for willow than for poplar. The seven *in vivo* digestibility coefficients were then used to develop a standard curve for *in vitro* prediction of *in vivo* digestibility; this standard was used to analyse all unknown tree fodder samples from the three grazing experiments.

Results from the three grazing experiments showed that supplementing ewes grazing drought pasture during mating with poplar and willow tree fodder consistently increased DM intake by 0.25 to 0.33 kg DM/ewe/day for ewes offered 1.3 to 1.5 kg fresh willow or poplar each day and increased calculated total DM intakes from 0.67 to 1.03 kg DM/ewe/day in Experiment 1, from 0.59 to 0.86 kg DM/ewe/day in Experiment 2 and from 0.47 to 0.75 kg DM/ewe/day in Experiment 3. Supplementation also consistently reduced LW loss and loss in BCS and substantially increased lambing rate through increased conception rate and fecundity and reduced post-natal lamb mortality. The effects on LW and BCS gradually declined in the post-

treatment period and were no longer evident by commencement of lambing. There was no effect of supplementation on wool production or staple length in any of the experiments. One of the unexpected results of the experiments was an average 34% reduction in post-natal lamb mortality over three years, due to willow/poplar supplementation of ewes during mating. Initial results showed that despite significant increases in fecundity in supplemented ewes in 2001 and 2002, post-natal lamb mortality was not increased. This result, combined with a statistically significant reduction in lamb mortality in Experiment 3 ($P<0.05$), in the absence of any differences in fecundity between the groups, suggested that tree fodder supplementation during mating may have reduced lamb mortality in all three years, but that the effect was masked by the increase in reproductive rate in the first two experiments. Therefore, data from the three field trials were combined and analysed by adjusting all mortality data to equal birth rank and sex; this showed a significant reduction due to supplementation ($P<0.05$) with no treatment-year interaction.

The increase in ewe production and reproduction in supplemented ewes was likely due to increases in nutrient intake, through increased DM, ME and CP intakes, prior to and during mating and to increased outputs of undegradable dietary protein and microbial protein from the rumen, per unit of crude protein consumed, thus increasing amino acid absorption. An increase in ovulation rate of 1.5 % units/MJ of digestible energy consumed (Smith 1985) should result in increases in ovulation rate due to tree fodder supplementation of only 5 and 4% units in 2001 and 2002, respectively; however, the increases in scanning rate were substantially greater at 41 and 16% units. Therefore, it is possible that the majority of the increase in reproductive rate was due to increased essential amino acid absorption, which is consistent with increases found in ewes mated on CT-containing forages such as *Lotus corniculatus* (Birdsfoot trefoil).

Gross margin analyses using actual data from unsupplemented ewes in each of the three grazing trials compared with Riverside Farm's commercial ewes from the same years showed that drought reduced scanning rates by an average of 22.4% and wool production by 20% and that this reduction decreases sheep production income by approximately $14/ewe. Further analysis showed that almost half the cost ($6/ewe) could be recovered by supplementing ewes with tree fodder in a drought. On a whole farm basis this represents $58/hectare cost benefit due to tree fodder supplementation.

Fungal contamination was a significant factor in the results obtained in Experiments 2 and 3. In all years, simulated drought pasture contained metabolites of zearalenone and the trichothecenes nivalenol and deoxy-nivalenol, produced by *Fusarium* fungi, while in Experiment 2 the poplar was severely contaminated with *Melampsora larici-populina*, or poplar leaf rust. Zearalenone concentrations in pasture were at their greatest in Experiment 3 and increased to over 2 mg/kg DM during the mating period. This may explain the lack of increase in reproductive rate expected in willow-supplemented ewes in Experiment 3, which was a feature of previous experiments; however, it did not explain the much greater loss in ewe LW in Experiment 3. Nivalenol (NIV) and deoxy-nivalenol (DON) are common trichothecene toxins found in New Zealand pasture and were found in pasture samples from all three experiments; however, the concentration in Experiment 3 was three- to four-fold greater than in previous experiments. Reports have suggested that trichothecenes may be partly responsible for the reduced growth of otherwise healthy livestock grazing dry autumn pasture, often referred to as 'ill thrift'. However, based on evidence from dosing experiments, it is unlikely that the quantities of NIV and DON present in pasture in Experiment 3 accounted for all of the greater LW loss seen in this experiment. This suggests that these toxins are likely to be indicators of other more potent fungal toxins, which have a much bigger impact on livestock health and production. It is likely that fungal toxins contribute more to reduced reproduction in breeding ewes and to ill thrift in young stock grazing dry autumn pastures in East Coast regions than is currently acknowledged.

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| | |
|---|---|
| ADF | Acid detergent fibre |
| BCS | Body condition score |
| Ca | Calcium |
| CHO | Carbohydrate |
| cm | Centimetre |
| CP | Crude protein |
| CT | Condensed tannin |
| D | Diameter (mm) |
| DBH | Diameter at breast height |
| DM | Dry matter |
| DMD | Dry matter digestibility |
| DMI | Dry matter intake |
| DM% | Dry matter percentage |
| DOMD | Digestible organic matter (g)/100 g DM |
| DON | Deoxy-nivalenol |
| EAA | Essential amino acids |
| ELISA | Enzyme linked immunosorbent assay |
| FA | Feed allowance (DM/ewe/day) |
| g | Gram |
| GLM | General linear model |
| ha | Hectare |
| HCL | Hydrochloric acid |
| HM | herbage mass (kg DM/ha) |
| IPO | Interdecadal Pacific Oscillation |
| IRI | International Research Institute |
| K | Potassium |
| kg | Kilogram |
| kph | Kilometres per hour |
| LIG | Lignin |
| LW | Live weight |
| m | Metre |
| M | Million |
| MAF | Ministry of Agriculture and Forestry |
| M/D | MJ ME/kg DM |
| ME | Metabolisable energy |
| Mg | Magnesium |
| MJ | Megajoule |
| mm | Millimetre |
| MW | Molecular weight |
| MWI | Meat and Wool Innovations |
| N | Nitrogen |
| NAN | Non-ammonia nitrogen |
| ND | Not determined |
| NDF | Neutral detergent fibre |
| NIV | Nivalenol |
| NV | Nutritive value |

| | |
|---|---|
| $NZ | New Zealand dollar |
| OM | Organic matter |
| OMD | Organic matter digestibility |
| P | Phosphorous |
| P | Probability |
| *P.* | *Populus* |
| PA | Paddock/grazing area |
| PG | Phenolic glycoside |
| pH | Measure of acidity |
| RDN | Rumen degradable nitrogen |
| *S.* | *Salix* |
| SAS | Statistical Analysis System |
| SE | Standard error |
| SO | Southern Oscillation |
| SOI | Southern Oscillation Index |
| t | Experimental period (days) |
| TGD | total grazing days |
| UDP | Undegradable dietary protein |
| VFA | Volatile fatty acids |
| VFI | Voluntary feed intake |
| WSC | Water-soluble carbohydrate |
| Z | Zearalenone |
| Zn | Zinc |
| μg | Micrograms |