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& DEVELOPMENT CORPORATION

Year round supply of

GOAT MILK

A report for the Rural Industries Research and Development Corporation

by Dr Alexander Cameron

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Researcher Contact Details
Dr Alexander Cameron
"Glenspean" Meredith 3333.

Phone:	03 5286 1211
Fax:	03 5286 1211
Email:	glenspen@netconnect. com.au

RIRDC Contact Details
Rural Industries Research and Development Corporation
Level 1, AMA House
42 Macquarie Street
BARTON   ACT   2600
PO Box 4776
KINGSTON   ACT   2604

Phone**:**	02 6272 4539
Fax**:**	02 6272 5877
Email:	rirdc@rirdc.gov.au.
Website:	http://www.rirdc.gov.au

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Foreword

Goat milk production is highly seasonal, being greatest in Spring and then declining to a nadir in Winter, yet relatively uniform year round supply of goat milk is needed because the high value goat milk manufactures have short shelf lives. The aim of the project was to determine the importance of seasonal changes in nutrition, reproduction and daylength in causing the seasonal variation in milk production, and to develop animal husbandry procedures to overcome any constraints caused by these factors.

Controlled experiments were conducted on each of the three areas, using animals and facilities at Meredith dairy, which is a commercial dairy located about 100 km west of Melbourne.

The key outcomes were the development of a ration capable of supporting milk production at levels obtained on abundant Spring pasture, and the establishment of a protocol for advancing the breeding season of goats from March to December, using the buck effect (a phenomenon whereby exposure to bucks stimulates does to ovulate).

In June, 1995, goat milk production at Meredith Dairy was less than one quarter of that in December. Through the adoption of husbandry procedures developed in this project, production in June 1999 reached 60% of that obtained in the previous December.

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Peter Core
Managing Director
Rural Industries Research and Development Corporation

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Executive Summary

The problem facing Meredith dairy when funds were sought was that goat milk production was highly seasonal, being greatest in Spring and Summer. For example in June, 1995, milk production was less than 25% of that obtained in December. Yet demand for milk was relatively uniform, because the highest value goat milk manufactures such as yoghurt and fresh curd cheeses have short shelf lives.

Factors considered likely to cause the seasonal pattern of milk production were nutrition, because the quality and quantity of pasture peaks in Spring and; seasonal reproduction, because goats are seasonally polyoestrus, with regular oestrus cycles commencing in autumn, leading to most kids being born in Spring. Together these factors mean that in Spring the goat herd is typically in early lactation and well fed, whereas by late autumn the goats are in late lactation and probably pregnant, and also unable to eat sufficient pasture to maintain high milk output. It seemed possible that the short daylengths in winter may also directly lead to reduced milk output, as this had been demonstrated in sheep.

The aim of the project was to investigate these factors with the objective of achieving relatively uniform milk production.

RESULTS

Nutrition

A controlled experiment was conducted with the aim of formulating a feedlot ration capable of supporting peak lactation, thus preventing pasture quality or quantity from constraining milk production.

In October 60 Saanen goats in the first three months of lactation were randomly assigned to one of three treatments; one group received ad lib pasture and 1.2 kg grain per day; a second group received 1.2 kg grain and ad lib silage (made from perennial ryegrass and subclover, and consisting of 19.1% protein and 9.9 MJ ME per kg drymatter), and a third group was fed ad lib silage and ad lib grain. Mean silage intake was 1.18 and 1.12 kg dry matter per day for the goats in second and third groups, respectively, and the third group ate 1.85 kg wheat per day.

Neither the volume or composition (per cent fat and protein) varied significantly between the 3 groups. Live weight rose in the groups fed silage, and fell in those at pasture. The silage based rations cost a total of 12 cents per litre of milk, and thus provide a cost effective ration capable of supporting peak milk production.

Overcoming the seasonal constraints to reproduction.

Several strategies were investigated:

(a) The use of daylength and melatonin which involved exposing does to 17 h lighting for 9 weeks, commencing on June 20, and then administering melatonin for 8 weeks using subcutaneous implants. Bucks were introduced 5 weeks after melatonin treatment began. All 17 does cycled in Spring and gave birth in autumn. Unfortunately the implants are no longer available in Australia, precluding the future use of this technique.

(b) The use of exogenous hormones, namely pregnant mare serum gonadotrophin (PMSG), after withdrawal of progestagen implants. Within a herd of 80 goats, 32 received 400 or 600 iu PMSG, either 48 h before, or at the time of withdrawal of progestagen sponges in early December. All the does came into oestrus but only 7 gave birth. Significantly, though, 18 of the non experimental goats gave birth. This striking example of the buck effect, whereby the sudden introduction of bucks to previously isolated does triggers one or more oestrous cycles before a return to anoestrus, was unexpected as the buck effect had not been described in dairy goats, and does not occur so early in summer in cashmere and angora goats.

(c) The efficacy of the buck effect was compared between three joining dates (December 1, December 30 and January 26), with melatonin implanted into half the does 4 weeks before joining. Furthermore within each group half the does received 25 mg progesterone one day before joining, while the other half received a progestagen implant for 12 days before joining. Half the does came into oestrus, independent of joining date, perhaps because the does in the last two groups had not been sufficiently isolated from bucks before joining. Treatment with melatonin had no effect, and neither did the type of progestagen treatment. In a follow up experiment we attempted to enhance the efficacy of the buck effect by exposing goats to continuous lighting for two months, and then to natural light for a further two months before joining on January 2. The lighting treatment had no effect, but the overall pregnancy rate (27/36) exceeded the performance indicator of 60% sought in the original grant application.

Direct effects of photoperiod on lactation

A statistically significant effect of providing artificial light in winter on milk yield was not demonstrated, but further experiments with larger numbers will be conducted, as there was a trend toward extra production when lighting was provided.

IMPLICATIONS:

When planning the project we suggested that low winter milk yields were a consequence of highly seasonal reproduction, inadequate nutrition, and perhaps inadequate lighting. These factors no longer need be an impediment to the supply of year round milk because the nutritional constraint can be overcome with a cost effective silage and wheat based diet, and the breeding season can be advanced by up to 4 months by isolating does completely from bucks, and then exposing them (the buck effect).

COMMERCIAL OUTCOME:

In June 1995, milk production at Meredith dairy was less than one quarter of that in December, whereas in June 1999 milk production represented 60% of that obtained in the preceding December.

RECOMMENDATIONS:

1. That information on the buck effect be circulated among goat farmers.

2. That further work aimed at refining the use of the buck effect be supported.

1. Introduction.

The problem facing Meredith dairy in 1996, when funds were sought, was that goat milk production was highly seasonal, yet relatively uniform year round milk supply was needed, because the high value goat milk manufactures such as yoghurt and fresh curd cheese have short shelf lives.

Typically milk production is greatest in Spring and Summer, and reaches a nadir in Winter. At Meredith dairy, production in June, 1995 was less than 25% of that obtained in December. Only one other dairy in Victoria attempted to provide milk all year round.

Factors considered likely to contribute to this seasonal production included:

Nutrition The quality and quantity of pasture is seasonal, with both parameters peaking in Spring.

Seasonal reproduction. Goats typically commence regular oestrous cycles in early Autumn, and return to anoestrus in late winter. Thus most dairy goats give birth in early Spring, and are in late lactation in early winter. This seasonal pattern of reproduction is entrained by the annual variation in daylength, with declining daylength stimulating the reproductive system. This effect of daylength is mediated by melatonin; a hormone released during periods of darkness so that short days lead to prolonged melatonin secretion.

Photoperiod. Ewes maintained under long day lengths have been shown to produce more milk than those in short day lengths (Ortavant et al, 1987). As goat reproduction is influenced by photoperiod, so too might their milk production.

The aim of this project was to investigate each of these factors with the view to overcoming the seasonal decline in winter milk production.

2. Experimental Program

Controlled experiments were conducted in each of the three areas outlined above using animals and facilities at Meredith dairy, which is a commercial dairy located approximately 100 km west of Melbourne.

1. Nutrition: Formulation of a ration capable of supporting peak lactation.

The multiparous saanen goats used in this experiment had kidded in August or September and prior to the commencement of the experiment were grazing pasture, and also received 0.6 kg whole wheat at each milking. The pasture consisted principally of perennial ryegrass and sub clover, and had been well fertilized (23 kg P per ha for the preceding 5 years). Pasture availability at the commencement of the experiment was 2,900 kg/ha. The goats had access to sheds for shelter.

On October 24 a total of 60 saanen goats, producing at least 2.15 litres of milk per day, were randomly allocated to one of three treatments:

Pasture and grain. This group continually were run as described above.

Silage and 1.2 kg grain. This group was housed, and had ad lib silage. The silage was made from early cut perennial ryegrass, and consisted of 42.7% dry matter, which in turn consisted of 19.1% protein, and 9.9 MJ ME per kg. During the course of the experiment mean silage intake was measured at 1.18 kg per day. The grain was fed at milking.

Silage and ad lib grain. This group was fed silage and grain as for the previous group, but also had constant access to a feed trough containing whole wheat. Mean silage intake was 1.12 kg per day, and wheat intake was 1.85 kg.

The treatments were applied for 3 weeks, at the conclusion of which milk volume and composition, and liveweight was recorded.

Table 1. Changes in milk yield and liveweight after 3 weeks of treatment.

Treatment	Change in volume (ml) Mean ± SE	Change in weight (kg) Mean ± SE
Pasture & grain	-54 ± 128	-0.9 ± 0.6
Silage & grain	- 4 ± 183	2.4 ± 1.0
Silage & ad lib grain	442 ± 152	2.0 ± 0.5

The results (tables 1 and 2) demonstrate that the goats housed and denied access to pasture maintained yields similar to those at pasture. Those fed grain ad lib appeared to have increased production, although the differences are not significant. At current wheat and silage prices ($130 and $150 per ton respectively) the ration for those goats fed ad lib hay and silage cost 41 cents per day, or under 12 cents per litre of milk.

Table 2 Volume and composition of milk, and total yield of fat and protein at the end of the 3 week treatments (Mean ± SE).

Treatment	Volume ml	Percent fat	Percent protein	Total fat (g/d)	Total protein (g/d)
Pasture & grain	3060±180	3.2±0.12	3.1±0.07	99±6.9	93±5.0
Silage & grain	2990±123	2.9±0.16	3.0±0.11	87±5.7	88±4.5
Silage & ad lib grain	3608±207	2.9±0.16	2.9±0.08	96±5.7	100±7.1

In conclusion this experiment demonstrated that goats can be fed a cost effective ration that maintains peak milk production. This ration was used in the remaining experiments.

2. Overcoming the seasonal constraints to reproduction.

a. The use of daylength and melatonin.

This was essentially a field trial of a technique developed by Deveson et al (1992), and was carried out in the commercial dairy of J. Hall at Childers. Seventeen does were exposed to 17 h daylengths for 9 weeks, commencing on June 20 (does subjected to short daylengths for prolonged periods become refractory to the stimulatory effects of short days; exposure to long daylengths re-sensitizes them). Melatonin was then administered as subcutaneous implants (Regulin, Schering), for 8 weeks (which was expected to have the same effect as exposure to short daylengths). The buck was introduced 5 weeks after melatonin treatment began. Oestrus was first observed 5 weeks later, and all 17 does gave birth in autumn.

Unfortunately melatonin is no longer available as long acting implants in Australia.

b. The use of exogenous hormones.

Pregnant mare serum gonadotrophin (PMSG) has gonadotrophic activity when administered to goats, and will thus induce oestrus. An experiment was conducted within the herd of 80 lactating dairy goats with the aim of determining the optimum protocol for using PMSG. Within a herd of 80 lactating dairy goats 32 were treated with progestagens for 14 days. Either 400 or 600 i.u. PMSG (pregnecol, Novartis) was administered at either the time of sponge withdrawal, or 48 h earlier. The timing of the treatments was staggered such that sponges were withdrawn from 4 goats each day, so that the two bucks that were joined, which were also at a period of relative sexual quiescence, did not have too many goats to mate at any one time. The two bucks were joined to the does from November 29, until December 12.

All of the 32 does were observed in oestrus, but only 7 gave birth. The cause of this poor fertility is not known, and is being investigated this spring, with the initial aim of determining whether the does actually ovulate in response to the doses of PMSG used. An alternative possibility is that the bucks failed to mate the does. This possibility arose because of the most significant observation in this experiment which was that 18 of the does that were untreated became pregnant. This was a striking, but unexpected, example of the ‘buck effect’, whereby the introduction of a buck to previously isolated does may induce them to ovulate (Chemineau, 1983). The result was striking, because in previous experiments of ours (Cameron and Batt, 1989) and others (McGregor et al, 1985) in angora and cashmere goats the buck effect did not occur until late January. Furthermore there was no anecdotal evidence of this occurring earlier in dairy goats (perhaps because most goat dairies are on small areas so that bucks and does are never completely segregated).

This serendipitous finding of a pronounced ability of bucks to induce oestrus in late November led us to modify the experimental program with a view to investigate its practical applications. A frustrating aspect of such research is that because isolation from bucks is a prerequisite for subsequent oestrous induction, it is difficult to carry out more than one experiment each year. In consequence further experiments aimed at optimising the buck effect are still being carried out.

c. The use of the buck effect.

An experiment was conducted to determine how the proportion of does induced to ovulate by exposure to bucks was effected by the date of exposure, and whether the proportion responding was enhanced if exposure was preceded by the administration of melatonin (which increased the proportion of Angora does ovulating in January; McGregor et al, 1987). Furthermore the effect of either a single injection of progesterone (which prevents premature regression of the corpus luteum which often occurs at the buck induced ovulation; Chemineau, 1985), or of progesterone sponges prior to exposure to bucks was determined. These factors were examined in a 3 X 2 X 2 factorial experiment, with 4 lactating does per cell. The factors were:

Date of joining: December 1, December 30, January 26.
Melatonin: Regulin 4 weeks before joining or untreated.
Progesterone: Sponge for 12 days before joining, or 25 mg progesterone in oil, 1 day before joining.

The does were housed for 2 weeks with one buck. Two oestrus does were added to the group at the same time as the buck as our own work in angora goats, and the work of Restall et al (1995) in cashmeres has demonstrated that these increase the proportion of does ovulating. The does were observed twice daily for oestrus.

The proportion of does observed in oestrus varied little with joining date (9/16, December 1; 6/16 December 30; 9/16, January 26). The good response in early December was pleasing as this was three and one half months before the onset of the breeding season in the main dairy herd at Meredith dairy.

In hindsight we believe that the period of isolation between matings was too short to permit a proper comparison between the three joining dates. We intend to repeat this experiment, but in dry goats so that the groups can be kept well apart, which is not possible with the milking herd.

Pregnancy rates were disappointing, with 5 goats impregnated in the first group, but only 2 and one impregnated in the second and third group respectively. With only one buck being used it is impossible to know the cause of the poor fertility.

Treatment with melatonin had no beneficial effect on the proportion in oestrus (8/24 with melatonin and 16/24 without). This was surprising as it has been shown to be advantageous in angora goats. The practical significance was reduced because melatonin implants are no longer available.

The type of progestagen treatment also had no effect on the proportion of does in oestrus (12/21 with sponges, 12/27 with progesterone in oil; 3 does lost sponges leading to the unequal groups).

d. Manipulation of photoperiod to enhance the buck effect.

The only commercially available melatonin implant is no longer sold, so we attempted to manipulate reproduction using photoperiod, without melatonin as an adjunct. Thus 37 first lactation does were randomised into two groups, of which the control group received natural light, and the treatment group was subject to continuous light in September and October and then natural lighting in November in the hope that this would be perceived as a transition to short day length. Both groups were treated with 20 mg progesterone (to prevent luteal regression), the day before being joined to 3 bucks on January 2. For the first 2 days of joining 4 oestrus does (does that received 400 i.u. PMSG following 6 days treatment with progestagen) were added to the mating group in an attempt to enhance the buck effect (Restall et al, 1995).

The result was that 14/19 treated animals were pregnant, compared to 13/17 controls. The birth dates indicated that 17/27 does were impregnated within the first week of joining, and the remaining 10 were impregnated in the following week, indicating they had a short cycle (which the progesterone injection is claimed to prevent (Chemineau, 1985). No does returned to service after a full length cycle. The finding that most goats were impregnated at the first ovulation after bucks were introduced indicate several days of circulating progesterone before ovulation is not necessary to prepare the uterus for pregnancy. This is contrary to the situation in sheep, and thus contrary to what had been assumed to apply to goats.

This experiment failed to indicate a benefit of lighting, but did achieve an overall pregnancy rate of 75%, which exceeded the performance indicator of 60% sought in the grant application.

3. Determine the effects of photoperiod on lactation.

It was planned to run a group of does on a reverse photoperiod by subjecting them to increased lighting in Winter, and to melatonin treatment in Summer. The unavailability of melatonin implants precluded this approach and instead several more discreet experiments were conducted.

a. <u>The effect of melatonin on lactation</u>

The aim was to determine whether exogenous melatonin, (which is normally elevated during darkness) inhibited milk production. Forty eight lactating does were randomly allocated to an untreated control group, or a group receiving a melatonin implant. Milk yield was recorded at the beginning and end of the 4 week treatment. Yields declined by 90 ml in goats that received melatonin, and by 220 ml in the controls, demonstrating that melatonin does not inhibit milk production.

b. <u>The effect of lighting on milk production in winter for does in late lactation.</u>

Twenty six does that gave birth the previous August, and were 8 to 12 weeks pregnant, and were still yielding at least one litre of milk per day, were randomly assigned to two groups, the first of which was maintained under natural light, while the second group was maintained under 24 hours light for 4 weeks, commencing May 15. The result was that daily milk production declined at about the same rate (25 ml per week, and 32 ml per week) for the respective groups.

c.<u>The effect of lighting on milk production in winter for does in early lactation.</u>

Does that gave birth in early June were randomly allocated to either a control group that received natural lighting, or a group exposed to continuous light for 4 weeks, commencing July 2. Milk production (ml/day) rose in the treated groups in the next 4 weeks by 160 ± 95, whereas it fell in the control group by 170 ± 140 (mean$\pm$S.E.) The difference was not statistically significant, and even if real represented only a 15% difference between the groups, compared to the 40% claimed in sheep. Nevertheless, we will be repeating the experiment next year, as the goats are easily housed in winter at Meredith dairy, so lighting is easily achieved, so may still be commercially justified.

d. Lactation curves for animals commencing lactation in autumn or winter.

This year is the first in which we will be able to compare yields and lactation curves for does commencing lactation curves at different times of the year, without the results being confounded by factors such as the effect of pregnancy. This will assist in determining whether factors other than stage of lactation and pregnancy affect milk yield at different times of the year.

3. Implications

When planning this project we suggested that low winter milk yields were probably a consequence of highly seasonal reproduction, inadequate nutrition, and possibly inadequate lighting. We no longer believe any of these factors need be a major impediment to the supply of year round milk.

The nutritional constraint has been overcome with an economical silage and wheat based diet.

The seasonal pattern of reproduction has been shown to be extended by up to 4 months by the use of the buck effect. In our last experiment we obtained a 75% pregnancy rate in early January, which exceeded our aim at the start of the project. Further work is planned to ensure the use of the buck effect becomes a predictable management tool. At Meredith we now mate does at 4 times of the year; January, April, July and October, with a view to providing an even supply of milk. We are now confident of achieving satisfactory pregnancy rates on the first three of these dates. We have work in progress aimed at optimising the use of progestagens and PMSG in October. We are also defining the end of the breeding season, knowing that some goats cycle as late as September. If we can reliably mate does naturally in late August, we may not need to mate in October.

We remain unsure as to whether other factors such as daylength reduce milk yields in winter compared to spring. As our ability to mate does at different times of the year has increased, we are now able to begin comparing lactation curves for does kidding at different times of the year, without confounding effects of animals being at different stages of pregnancy, or different times after parturition.

COMMERCIAL OUTCOME

In June, 1995, milk production at Meredith was less than one quarter of that in December, whereas in June 1999, milk production represented 60% of that obtained the previous December. Gross sales have trebled in the past three years. Our success has led to other factories demanding year round supply.

4. Recommendations

1. That an information sheet about the use of bucks to extend the breeding season of does be prepared and circulated among commercial dairy goat farmers.

2. That further work aimed at refining the use of bucks be supported.

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