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Fecal egg counts and individual milk production in temperate pastoral dairy systems of Australia

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Abstract: Anthelmintic use in lactating dairy cattle, has been shown to result in a milk production response in some previous studies. If individual animals within a herd could be identified that would most benefit from anthelmintic treatment, this may reduce anthelmintic resistance. Australian dairy systems are predominantly pasture-based, allowing sustained exposure and immune stimulation of cattle to gastrointestinal nematodes. We assessed the relationship between milk production and early lactation fecal egg counts (FEC) to determine whether cows with higher FEC produced less milk. Ten pasture-based dairy farms in south-west Victoria, Australia, entered an observational study. Individual FECs at a minimum detectable count of 2.5 eggs per gram of feces (epg) were recorded for recently calved primiparous and multiparous cohorts on each farm. All animals were calved ≤ 30 d at sampling. Body condition scores were assessed at sampling and milk production data was collected from daily milk meters and herd tests to give first 100-d milk production. When separated by primiparous or multiparous status, no difference in the milk production between cows with FEC = 0 and FEC ≥ 2.5 epg was identified. Between farm variation was large for FEC and milk production. Fecal egg count at a minimum detectable count of 2.5 epg detected parasitism in primiparous cows post calving but the presence and magnitude of parasitism measurable by FEC was not related to milk production in pasture based Australian dairy systems. In multiparous cows, the rate detection of worm eggs at this analytical sensitivity was lower and the significance of a positive FEC at this analytical sensitivity requires further assessment to ascertain the effect on milk production. Based on our study, it seems unlikely that individual FEC results would be useful as a basis to select individual cows in southwest Victorian dairy herds for anthelmintic treatment.

Gastrointestinal nematodes are parasites of cattle that must be managed rather than eradicated. While they can cause clinical disease in young naïve stock (Hilderson et al., 1993), the need for management and treatment in adult dairy cattle has been a contentious topic with varying findings (Charlier et al., 2012; Geurden et al., 2017; Ravinet et al., 2014).

Gastrointestinal nematodes can inflict damage upon abomasal and intestinal wall structures resulting in diarrhea and poor weight gain, but as naïve cattle are exposed to gastrointestinal nematodes, they build resistance and resilience (Hilderson et al., 1993).

As the host immunity against gastrointestinal nematodes develops, the ability for worm egg production is reduced by the host. With stronger immunity, the host cow is able to expel adult worms (Vercruyse and Claerebout 1997). In a Canadian study, where cattle were at pasture, primiparous cows were 4.5 times more likely to have a detectable FEC when compared with multiparous cows (Nødtvedt et al., 2002). A recent local study, of which this manuscript's data is a subset, illustrated that herds in south-west Victoria have low FECs, and that 45% of primiparous and 26% of multiparous cows have an FEC ≥ 2.5 epg (Loughnan et al., 2024).

The effect of minor worm burdens on adult dairy cattle and their productivity has been examined repeatedly (Forbes et al., 2004; Mejía et al., 2011; Perri et al., 2011). Local research in south-west Victoria illustrated a 74L increase in production over the first 100 d of lactation for anthelmintic treated cattle, a 3% milk yield benefit (Walsh et al., 1995). Walsh et al. found no alteration to the milk production response with relation to parity, presence of positive

FEC or body condition score (BCS). Similar to these findings by Walsh et al., (1995), several international studies in the northern hemisphere have illustrated varied milk production increases among anthelmintic treated cattle (Nødtvedt, 2002; Ravinet et al., 2014; Verschave et al., 2014). These international studies all include herds with cattle housed for a portion of the year and they vary in the approach to timing of treatment, the milk production increase ranges from 0.85 to 0.97kg/milk/day in these 3 studies.

New Zealand research illustrated an inconsistent milk production response to repeated anthelmintic use across half a herd throughout lactation (Mason et al., 2012). These animals were allowed to come into contact and groom post application of topical anthelmintic. Laffont et al., (2001) illustrated that > 60% of topically applied ivermectin achieves eventual fecal excretion because of licking behavior, meaning that selective treatment in comingling cows is likely to have varied responses to therapy.

A meta-analysis of studies investigating the milk production response to anthelmintic treatment was completed in 2004 (Sanchez et al., 2004). Overall, this analysis indicated that 40/75 studies found a positive milk production response associated with anthelmintic use, whereas 34/75 could not establish a relationship between treatment and production. One study in this meta-analysis showed a negative association between treatment and milk production.

In another approach, research in Argentina has illustrated a milk production difference between cows with a positive FEC and those without a positive FEC at an analytical sensitivity of 10 epg (Perri

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The list of standard abbreviations for JDSC is available at [adsa.org/jdsc-abbreviations-24](https://www.adsa.org/jdsc-abbreviations-24). Nonstandard abbreviations are available in the Notes.

et al., 2011). Cows with a positive FEC at or just before calving produced 7–12% less milk than their counterparts with a FEC of 0 epg.

One study in the UK where anthelmintic was used mid lactation suggested marginal milk production increase but also an increase in grazing and ruminating time of anthelmintic treated cows, indicating an increased appetite post parasite removal (Forbes et al., 2004).

Given the inconsistency of findings around treatment responses to anthelmintics in lactating dairy cattle the importance of this topic has greater implications than just the possible liters of milk gained due to treatment. Local trials have shown broad reaching anthelmintic resistance to all classes of available anthelmintic for dairy and beef cattle (Bullen et al., 2016; Rendell 2010). Blanket use of anthelmintics in lactating dairy cows is contributing to the development of drug resistance and may be a cost that does not give a return.

We aimed to test the hypothesis that cows with a measurable worm burden, by fecal egg count, would have a lower milk production than their peers without a measurable worm burden at an analytical sensitivity of 2.5 epg of feces.

Ten herds from south-west Victoria, Australia, were enrolled in this study. Herds were selected based on convenience, locality, production system (seasonal or batch calving system to ensure sufficient subjects available), ease of testing due to facilities and interest from farm to be involved in study. Eligibility involved being pasture based dairy herd in south-west Victoria. Herds with daily milk volume assessments were sought out as study participants to accomplish our aim of production assessment with relation to worm burden. Primarily the herds were selected based on being clients or contacts of the primary researcher.

Herd records from local farms were used to estimate parameters in a power calculation. We considered an increase of 150 L over 100 d to be a biologically important difference. Based on an expected 100-d production of approximately 3500L with a standard deviation of 500 L and a positive FEC proportion of 50%, a total of 250 cows would be needed for an 80% power to detect a difference in production of 5%.

All herds were pasture based grazing operations where cows grazed pasture daily and were supplemented with additional feed in the bail, some farms utilized feed pads for ration supplementation. Anthelmintics were utilized on some but not all farms and date of most recent anthelmintic use was recorded for each cow; the most recent was 59 d before fecal sampling for one individual. This study examined the fecal egg count at a point in time and its relationship with milk production, therefore the anthelmintic use was not considered relevant in this data set due to time since treatment in all study participants.

Samples were all collected between 1st June 2020 to 6th October 2020. Cows sampled were selected by the farm manager based on age and calving date, all were < 30 d in milk (DIM) at the time of sampling. Farm managers selected 15 primiparous cows and 15 multiparous cows, each group of multiparous cows included 3–4 animals from each age cohort: 3 year old, 4 year old, 5 year old and 6+ year old.

Fecal samples were collected directly from the rectum and transferred into a numbered collection tray. Fecal samples were sent at room temperature via Express post to arrive at a commercial laboratory within 48 h.

Cows were condition scored on a scale of 1–8 (Dairy Australia 2013) by the same practitioner at the time of sampling and identification numbers were recorded to correlate with samples to allow for analysis and later comparison.

Individual animal fecal egg counts were assessed down to an analytical sensitivity of 2.5 (epg) using the Mini FLOTAC technology in a ParaBoss-accredited laboratory. The Mini FLOTAC procedure regularly counts down to an analytical sensitivity of 5 epg; for our study, the Mini FLOTAC procedure was run twice, per sample, to increase the analytical sensitivity to a level of 2.5 epg.

A selection bias occurred to include several herds with daily milk monitors which resulted in sampling from more rotary herds with greater incorporation of technical equipment. Participation was optional and testing was free to the participant.

During analysis and data cleaning, cows who calved >30 d before date of sampling were excluded from all analysis. Cows were removed from the data set where they produced less than 500L in the first 100 d of lactation or where they did not record a lactation > 100d in length. Three cows recorded production of < 500L over the first 100 d and were deemed to have incomplete data sets. After exclusions, all cohorts consisted of ≥10 cows and the lowest individual production record was 1235L.

Milk production data were collected from farms with daily milk volume meters for individual cows (n = 6) and farms where intermittent whole herd testing was undertaken (n = 4).

Milk production in the first 100 d was calculated in the daily meter farms by summing the milk volumes for d 5–100. On intermittent testing farms, d 5–100 production was estimated using a weighted average of herd test volumes from cows which had at least one test within 60 d of calving and where there was no more than 80 d between any individual tests.

Statistical analysis was explored using Jamovi 1.6.23 (The jamovi project 2021. Retrieved from <https://www.jamovi.org>). To reduce the effect of farm management, genetics, and nutrition on FEC and production, each animal was ranked on 100-d milk yield and assigned a quartile within their cohort. Graphs showing mean and range of FEC for each quartile were used to observe for relationships between FEC and 100-d yield quartile.

Overall, combining all ages of cattle and all farms into one data set produced 247 cows with individual FECs and corresponding milk production figures. Herd size ranged from 170 to 1010 cows with a mean herd size of 551 cows. Data obtained from daily milk meters comprised of 141 individual milk production records and 106 were obtained from extrapolated herd test results. Larval cultures completed from the same sample set utilized in a parallel study found that 85% of all larvae were *O. ostertagi* (Loughnan et al., 2024). Of this data set, 45% of primiparous cows had a FEC ≥2.5 epg whereas only 25% of multiparous cows had a FEC ≥2.5 epg. Multiparous animals produced on average 3185 L in their first 100d of lactation in comparison with the primiparous cows 2255L.

Due to the much higher proportion of primiparous cattle with a positive FEC and their lower milk production the data was separated into primiparous and multiparous sets to avoid interference of the effect of parity on milk production and FEC.

Individual records were obtained for 107 primiparous cows from 8 farms. There was less than 25L difference in 100 d milk production between primiparous animals with a FEC ≥2.5epg and those with an undetectable or 0 FEC (2244L and 2268L respectively). This was considered to be biologically unimportant. Overall, 140

Table 1 – Comparison of mean 100 d milk production, sample size and standard deviation for primiparous and multiparous cows with FEC = 0 and FEC \geq 2.5epg

	FEC = 0 eggs per gram		FEC \geq 2.5 eggs per gram		P Value
	Milk production (L), (n)	SD	Milk production (L), (n)	SD	
Primiparous	2244 (59)	499	2268 (48)	428	0.8
Multiparous	3218 (100)	585	3103 (40)	877	0.37

individual FEC and corresponding milk production records were obtained for multiparous animals across all farms. There was a 115L difference in the 100 d milk yield between FEC = 0 and FEC \geq 2.5epg groups of multiparous cows as seen in Table 1.

The post-hoc decision to analyze primiparous and multiparous cows separately had an impact on the statistical power of our study. Post-hoc power calculations suggest that, given the production and variation observed in our results, the statistical power to detect a difference of 150 L over 100 d was only 38% in the primiparous cows and 21% in the multiparous cows. However, the differences we observed were less than 150L over 100 d in both groups. Thus, while we have no evidence that the production was meaningfully different, we are unable to make further inferences from our data.

A further limitation in calculating the effect of parasitism on milk production in our study was the observed variation in milk production between farms for both primiparous and multiparous cows. To remove the influence of individual farm management on production data and FEC, each animal was ranked among her cohort and placed into quartiles based on individual production level relative to their cohort where 1 was the lowest producing quartile and 4 was the highest. We assumed that if the level of parasitism was important, there should be a difference in the proportion of cows with a positive FEC between the top and bottom quartiles on each farm in terms of milk production. For both multiparous and primiparous cows, the variation in FEC was greatest in the highest producing quartile but no relationship between FEC and production quartile was observed (Figure 1).

Assessment of FEC (analytical sensitivity 2.5epg) and production on a farm-by-farm basis was attempted to reduce the bias of different management, feed and genetic inputs. For this analysis, some groups were omitted due to low (<30%) proportions of cows with positive FEC. Figure 2 A and B show the milk production difference between FEC positive and negative cows where > 30% of animals had a FEC \geq 2.5 epg.

No consistent relationship was observed between milk production and FEC, with some farms having higher milk production in cows with a positive FEC and some farms having lower production in cows with a positive FEC (Figure 2).

We did not observe a relationship between fecal egg count and milk production in primiparous cattle, in contrast to an Argentinian study (Perri et al., 2011) which found that, around calving, the proportion of positive FEC cows was significantly greater in the primiparous group (38% primiparous and 22% multiparous). Unshown data is quoted, stating a significant difference in milk production between FEC positive and negative animals within each parity however the overall data shown from their study encompasses all parities together (Perri et al., 2011). Overall, our primiparous cows, which had a much higher proportion positive FEC (45% vs 25% at 2.5 epg) produced 930L less in their first 100d.

In contrast to our findings, Perri et al. (2011), found that high producing cows with an FEC \geq 10 epg in the month pre or post calving were likely to produce around 7% less milk for the lactation. The level of parasitism evident in our data was not reflective of those found by Perri et al., who found 22% of multiparous animals had an FEC \geq 10 epg around calving, we recorded only 8% of multiparous cows with FEC \geq 10epg.

Walsh et al., (1995) found a milk production response to anthelmintic in all cows, despite this there was not a difference in milk production response to anthelmintic correlating to FEC, which is aligned with our data set indicating the lack of correlation between FEC and milk production in primiparous cattle. Contrary to this conclusion, a Belgian study noted a greater milk production response to eprinomectin application at calving in cattle with elevated FECs (Verschave et al., 2014).

Some studies have looked at milk production response to anthelmintics and have compared response to treatment between primiparous and multiparous cows (Geurden et al., 2017; Verschave et al., 2014). Verschave et al., (2014) reported milk production increase by kg of milk/cow/day, it may be considered more appropriate to report these production differences as a percentage to remain comparable between parity and regions/systems as primiparous cattle often produce less milk and therefore inherently have a smaller gross change in production. While Verschave et al. (2014) found a greater milk response to anthelmintic in cows with higher FECs, they found much higher mean FEC's in their study herds than was noted in our data set.

Previously reported production differences in anthelmintic treated animals may largely be related to appetite rather than feed conversion efficiency as illustrated in a European study (Forbes

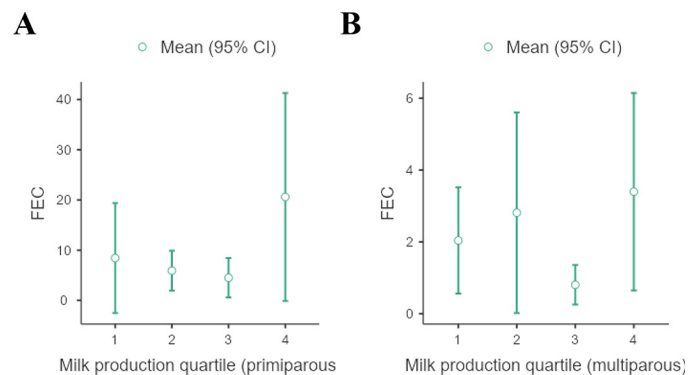


Figure 1. FEC with relationship to production quartile for Primiparous cows (A) and multiparous cows (B). Individual cows were ranked against their peers within parity and farm groups and assigned to a production quartile, these quartiles were assessed for distribution of FEC. Quartile 4 represented the highest 25% of individual milk yields on each farm.

et al., 2004). Forbes et al. demonstrated that the grazing and ruminating times in anthelmintic treated cows increased by around 50 min (7%) per day, following treatment the ME/kg DM of feces was not different for either anthelmintic treated or control animals. Much of the previous research indicating a milk production benefit from anthelmintic use did not measure feed intake or grazing time (Nødtvedt, et al., 2002; Ravinet et al., 2014; Verschave et al., 2014).

The choice to use an anthelmintic on lactating dairy cows is not without cost; the most obvious cost is the cost of the product and the labor to apply it. Additional feed costs associated with increased appetite as discussed previously (Forbes et al., 2004), should be considered in any cost benefit analysis.

Use of anthelmintics in blanket approach for lactating or calving dairy cows to achieve a production response assumes efficacy of product. Previous Australian work (Bullen et al., 2016), has illustrated the diminished efficacy and therefore likely diminished return on investment of the commonly used anthelmintic products for dairy cattle. Interestingly this study utilized the injectable an-

thelmintic treatment in young stock on dairy farms, injectables may have greater efficacy than the pour on products currently registered for use in Australian lactating dairy cattle. Anthelmintic resistance levels are unknown from the time of previous local work, which illustrated a milk response to anthelmintic (Walsh et al., 1995). It is highly likely that the efficacy of this product has reduced with more than 25 years of exposure to the same drug across many properties.

Contrary to international practices, Australian young dairy stock are raised on pasture and graze year-round in most operations. International research has shown that previous exposure to gastrointestinal nematodes increases host immunity (Eysker et al., 2000; Hilderson et al., 1993) and is likely to reduce the effect of parasites on growth and production (Ploeger et al., 1990). Further to this, one study in Canada found that herds where mechanical spreading of feces in pasture that heifers grazed correlated with lower FECs in adult cattle (Nødtvedt et al., 2002).

Whether or not anthelmintic treatment of dairy cows at a herd level would result in increased production was beyond the scope of

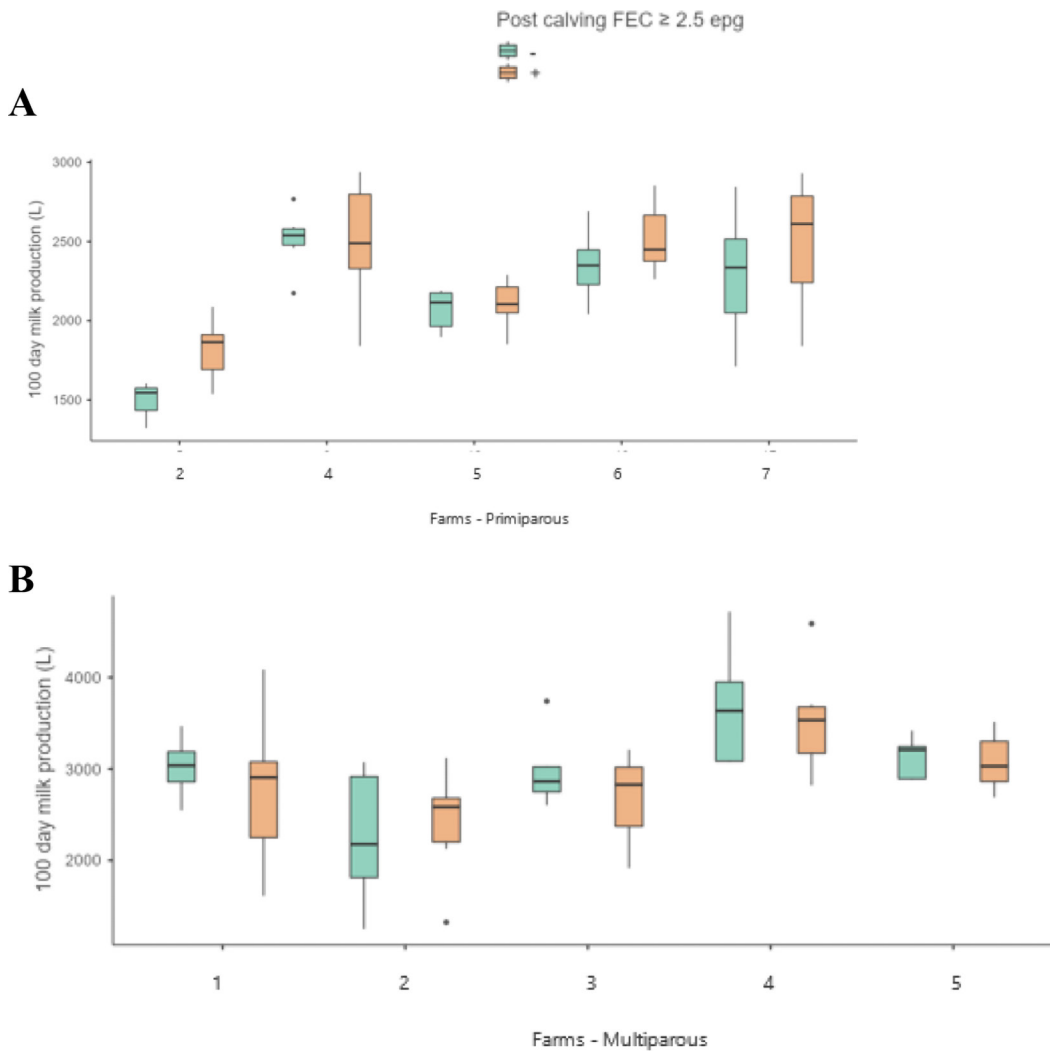


Figure 2. Milk production in cows with a FEC ≥ 2.5 epg post calving compared with their peers of FEC = 0 for Primiparous cows (A) and Multiparous cows (B) (Only includes farms where $\geq 30\%$ of cohort had a positive FEC)

our study. We did not see a biologically or economically important production difference in cows with or without a measurable FEC at sensitivities of 2.5 epg. Thus, our results do not suggest that individual FEC results would be useful for selective treatment of individual cows with anthelmintics. Further work is necessary to determine whether there is a basis to reduce blanket treatment of herds with anthelmintics based on individual test results.

However, our work may have implications for future studies. The much greater proportion of primiparous cows with positive FECs compared with multiparous animals (45% vs 25%) and their lower average milk production (2255L vs 3185L) required a re-design of the data analysis. The separate analysis of the primiparous/multiparous groups was not planned and hadn't been undertaken in similar studies (Perri et al., 2011; Verschave et al., 2014). One important implication of our study is that future researchers should consider carefully whether such a design should be a part of future studies.

Whole-herd anthelmintic treatment of dairy cows is commonplace and is likely to increase the development of anthelmintic resistance. This topic remains important for animal health, production efficiency and maintaining product efficacy into the future.

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Notes

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Conflicts of interest in this work are negligible, however one assisting Author is a Director of Dawbuts Laboratory where the Mini-Flotac procedure was completed and is available commercially.

Animal ethics approval for this study was given by The University of Melbourne. Cows in this study were subjected to routine management on com-

mercial farms. Manual fecal collection is a routine procedure in dairy veterinary and has no deleterious effect or lasting discomfort.