Transition Management Index: a new tool to assess the transition period success

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Abstract

An objective tool to assess the quality of the transition management practices is an important aid in maximizing the performance and profitability of dairy farms. Our objective was to create an index to assess the transition period of dairy cows using Canadian data (Transition Management Index; TMI) and benchmark current practices. The methodology was inspired by the Transition Cow Index® developed by Nordlund (2006). We used over one million DHI cow records from 2017-2020 from all provinces in Canada. included cows from lactation 1 to 7, from 8 breeds (Holstein, Jersey, Ayrshire, Brown Swiss, Guernsey, Canadian, Milking Shorthorn, and others), and 3 milking systems (pipeline, parlour, and robotic systems). Models were developed separately for primi- and multiparous cows using mixed-effect linear regression in R (*lme4* package) with the fixed variables breed, lactation start reason, milk testing scheme, age at first calving (primiparous only), milking frequency, and estimated breeding values for milk, fat, and protein, and a random herd effect. The models for multiparous cows also included previous lactation start reason, DIM, peak DIM, peak milk yield, 305-d milk yield, average somatic cell score (SCS), days dry, and lactation number. The TMI consists of the difference between the expected milk production estimated by the model and the 305-d projection at the first milk test (i.e., between 5-45 DIM), which also included DIM, beta-hydroxybutyrate (BHB), SCS, and 24-h milk yield.

The novelty of the TMI in comparison to the previous index is the inclusion of new traits potentially associated with transition management as well as the calculation of an index for first lactation cows. Results showed that the TMI herd average in 2022 was -27 (range of −1737 to 1334), and 49% of the cows had a negative TMI. Older cows have a lower TMI than younger cows (Lact 1 = 24; Lact 2 = -34; Lact 3+ = -55). Robotic herds had a greater average TMI (39) than pipeline (−54) or parlour systems (−100). There is a positive correlation (R = 0.64) between TMI and milk production. An increase of 100 points in the TMI is equivalent to an increase of 100 kg of milk and 3.5 kg of butterfat per standard lactation. A total of 5,070 Canadian herds were classified in percentiles according to the average TMI and their herd performance and profitability were compared. The top 20% of the herds have a daily milk yield 4.5 kg higher, produce 5.7 kg more milk at peak lactation, and produce 1,584 kg more milk and 62 kg more butterfat per lactation than the average. In addition, the top 20% of the herds have a yearly milk revenue of C$1,307/cow higher and a revenue per day of life of C$0.90/cow higher than the average. Higher herd TMI was associated with greater average milk value (R = 0.61), a lower SCC average (R= -0.35), and a lower percentage of cows with elevated or low MUN levels (R= -0.25). In addition, higher herd TMI was associated (R= -0.26) with shorter calving intervals. We are developing an interactive TMI dashboard to be launched in 2024. The main page features TMI cow records, annual averages, and provincial benchmarks, as well as KPI indicators

and drill-down functions on related transition management aspects such as udder health, energy status, rumen health, and dry period that enable producers and their advisors to assess the transition practices and identify opportunities for improvement.

Keywords: transition period, performance, management .
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Introduction

The transition period is considered the most challenging phase for dairy cows. During this period, nutrient imbalance is observed due to the higher metabolic demands and a decrease in feed intake (Bauman and Currie, 1980; Bell, 1995), consequently leading to an increased risk of oxidative stress (Sordillo and Aitken, 2009), reduced immune function (LeBlanc, 2020), and potentially higher inflammatory response (Contreras et al., 2018). Although those challenges are common to dairy cows during the transition period, a subset of cows may exhibit inadequate adaptation, leading to enduring consequences to performance throughout the whole lactation. Considering the impact of animal productivity on farm profitability, management programs need to be developed aiming to reduce the transition challenges and to quickly identify opportunities for improvement.

The results of the first test in the lactation provide insights into those challenges. A tool called Transition Cow Index™ (TCI) was developed in 2006 (Nordlund, 2006) to objectively evaluate transition management at the herd level. The tool uses fourteen factors from DHI records to project milk yield; and the first test date results to project the 305-d milk yield. Originally developed based on cow records from herds registered on the Wisconsin DHIA, the TCI is currently used in some provinces of Canada as a management tool. Nonetheless, advancements in management practices, along with enhancements in genetics and augmented milk yields, have been observed since 2006. In addition, using a Canadian index may reflect better the intricacies of the Canadian dairy industry. Therefore, our objective was to create an index to assess the transition period of dairy cows using Canadian data and develop an interactive dashboard to facilitate the use of the index.

Materials and methods

Model development

Data was extracted from the Lactanet database for lactations with a calving date between 2017 and 2020. This included animal and herd information, calving and lactation records including 305d milk production, test day records for the first test post-calving occurring between 5-60 DIM, dam deviations for production mature equivalents, and herd level production. Genetic evaluations were also available for all herdbook registered animals. Data included cows from all Canadian provinces and represented the seven dairy breeds in Canada, Holstein, Jersey, Ayrshire, Brown Swiss, Guernsey, Canadienne, and Milking Shorthorn, as well as crossbred or unknown breeds. Only lactations one through eight were retained due to the limited number of records in higher lactations. For first parity animals with a completed first lactation record and first test record in that lactation, further requirements were an age at calving between 18 and 47 months and herdbook registration. The final number of records was 373,297 for first lactations and 688,299 from later lactations.

Models were developed separately for first and later lactations due to the differences in data available for each group, where later lactations will have information on their previous lactation performance. The formulation of the models followed the general methodology described by Nordlund (2006) for the Transition Cow Index™. For each

of the first and later parity groups two models were developed, one to estimate the expected 305d milk production without any test day information ("prediction") and one to estimate the 305d milk production with the first test day record ("projection"). The "prediction" milk production minus the "projection" milk production represents the final TMI value of interest.

All models were created using mixed-effect linear regression using the lme4 package in R. Herd at test day was included as a random effect in the training model to account for variation due to the herd environment. Initially, all variables were included as fixed effects in their respective model. Polynomial terms were considered for some traits. Variables were retained if significant ($P<0.10$) in at least one of the two models following a combination of backward elimination and forward selection. The impact of variable inclusion on the final index values was also considered for retention, such that if variables more complex to implement had little impact, they were removed. A further consideration in variable selection was the degree of missing data for a trait to ensure the model would apply to a large proportion of the population. Final fixed variables included breed, lactation start reason, milk testing scheme, age at first calving (first lactation only), milking frequency, and estimated breeding values for milk, fat, and protein. Later lactation models also included previous lactation start reason, DIM, peak DIM, peak milk yield, 305-d milk yield, average SCS, days dry, and lactation number. The "projection" models included all the same variables as the "prediction" and further included DIM, beta-hydroxybutyrate (BHB), SCS, and 24-h milk yield at the first test.

Results and discussion

Relationship between Transition Cow Index™ and Transition Management Index

At the individual level, there was a strong correlation ($R=0.95$) between the TCI and TMI results for both lactation 2 and 3+ cows (Figure 1).

Descriptive analysis

At the individual level, the TMI average was -27 and 49% of the cows had an index below zero (Figure 2). The TMI average was slightly higher for Lactation 1 cows (25) than for Lactation 2 (-34) and Lactation 3+ cows (-55). However, the percentage of cows below zero was similar between lactation groups (Lact. 1 = 48; Lact. 2 = 50; Lact. 3+ = 50) (Figure 2). The TMI equation for Lact. 2+ cows incorporate additional variables due to the information about previous lactation, unavailable for Lact. 1 cows. Given this distinction, one might hypothesize that genetic parameters would exert a more significant influence on the TMI of Lact. 1 cows. However, a relative metrics analysis demonstrated that, apart from breed, no variable exhibited greater importance in the Lact. 1 equation.

The TMI average for herds with robotic milking systems (39) was higher than for herds with pipeline (-54) and parlour systems (-100). The higher average is accompanied by a lower percentage of cows with TMI below zero for herds with robotic milking systems (44.1 %) than pipeline (51.4%) and parlour milking systems (53.2%). In 2021, we compared the performance of Canadian herds according to the milking system (Brisson, 2021) and we also find a higher TCI for robotic herds in comparison to pipeline and parlour.

In general, Ayrshire herds had the lower TMI (-150) and the greatest proportion of cows with TMI below zero (58.5%), in comparison to Holstein (TMI = -39, % below 0 =49.9%) and Jersey herds (TMI = -81; % below 0 = 53.8%).

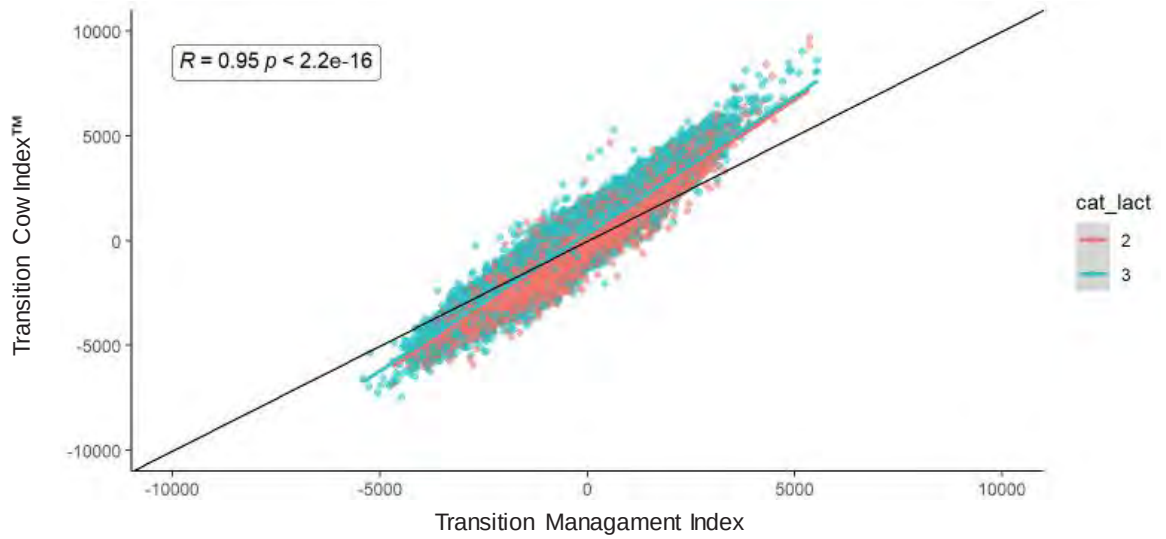

Figure 1. Relationship between the Transition Cow Index™ and the new Transition Management Index for cows from lactation category (cat_lat) 2 and 3+.

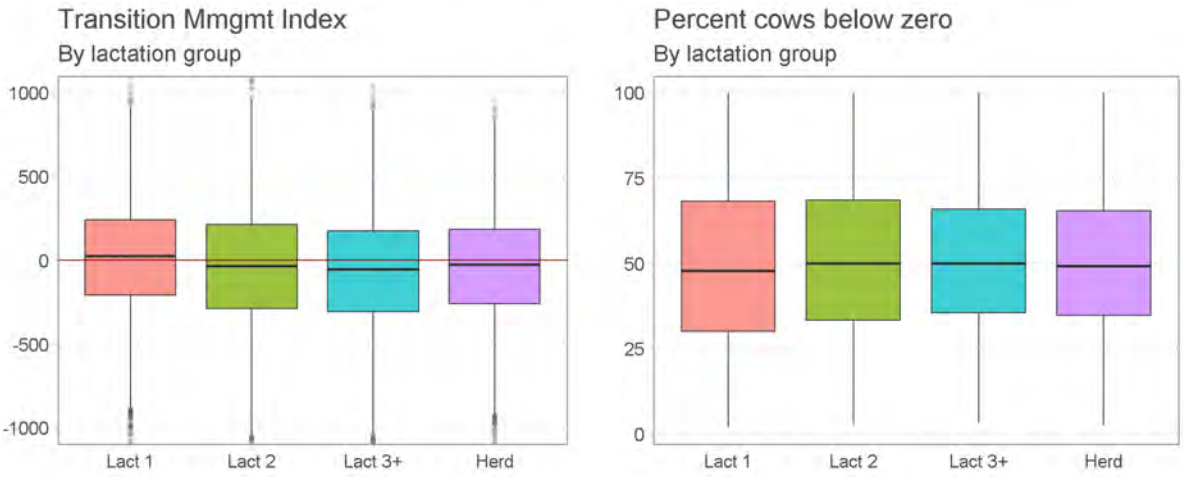

Figure 2. Transition management index average (left) and percentage of cows with a Transition Management Index below zero (right) according to lactation groups.

Relationship between Transition Management Index and performance

The TMI was correlated (R=1) with 305-day milk, and every increase in 100 points in the herd TMI is equivalent to an increase in 100 kg of milk and 3.5 kg of butterfat per standard lactation.

A total of 5,070 Canadian herds were classified in percentiles according to the average herd TMI, and those herds with the top 20% averages had a lower percentage of cows with negative TMI, higher milk and fat yield, had a higher production at peak, and a greater milk revenue than the average (Table 1).

The herd TMI average was negatively correlated with annual SCC average (R=-0.35), calving interval (R=-0.26), and extreme MUN values (< 8 mg/dL or >18 mg/dL; R=-0.25), and positively correlated (R=0.61) with milk value (Figure 3).

Transition Management Index dashboard

We created an interactive dashboard to present the results of the herd Transition Management Index. The dashboard main page contains the TMI herd average, the % of animals with a negative index, the average of the current test, and a graph where is possible to assess individual TMI values. It also contains information about key

Table 1. Production and profitability parameters of 5,070 Canadian herds classified in percentiles according to the average herd Transition Management Index (TMI).

	Herd Percentiles					
	0-20	20-40	40-60	60-80	80-100	Average
TMI	-534	-188	-10	155	419	-49
Cows with negative TMI, %	78.9	60.7	48.2	36.7	23.3	50.6
Milk yield, kg/day	22.6	26.3	27.7	29.8	32.0	27.5
Fat yield, kg/day	0.94	1.11	1.16	1.25	1.33	1.15
Protein yield, kg/day	0.76	0.89	0.94	1.01	1.07	0.93
Milk yield, kg/year	8,362	9,708	10,226	10,890	11,701	10,117
Fat yield, kg/year	342	400	421	446	477	415
Protein yield, kg/year	279	326	344	365	391	339
Milk at peak lactation, kg	34.6	39.0	40.9	43.2	46.3	40.6
Days to peak lactation	45.6	47.1	47.0	47.6	47.7	47.0
Milk revenue, $/cow/year	4,625	5,679	6,023	6,755	7,289	5,982

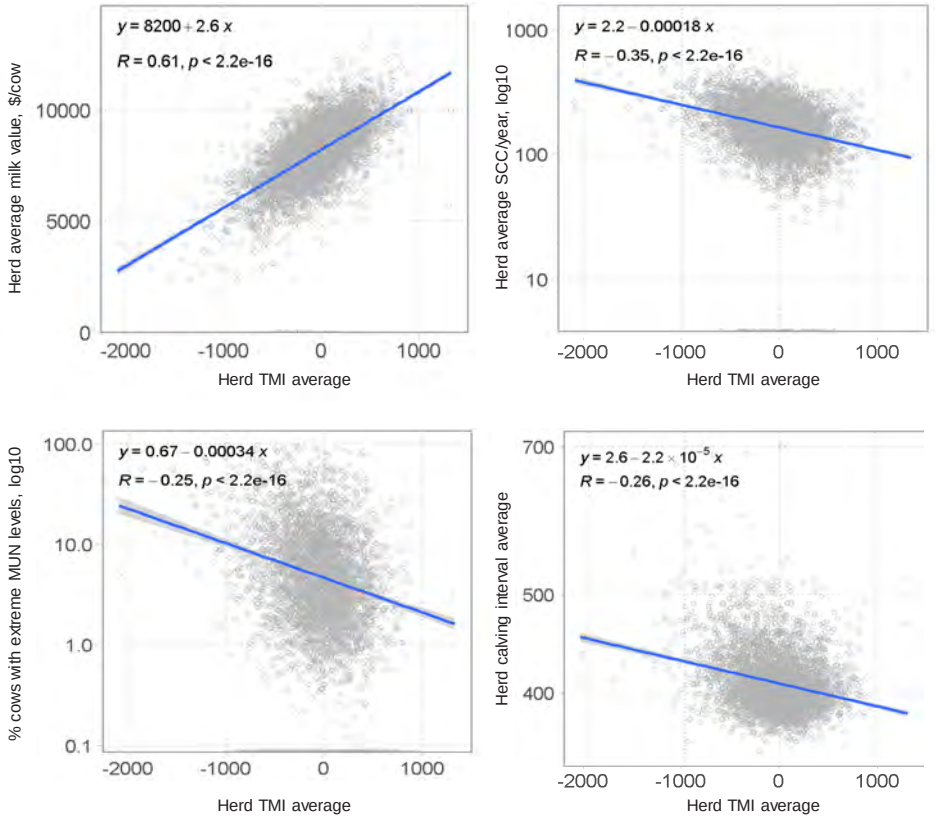

Figure 3. Relationship between herd Transition Management Index and herd average milk value, SCC, % of cows with extreme MUN levels, and calving interval.

performance indicators (KPIs) at transition period, such as udder health, energy status, and ruminal health, dry period length, among other information. Each one of those indicators has its tab, which brings more information about each KPI in early lactation, helping to identify opportunities for improvement (Figure 4).

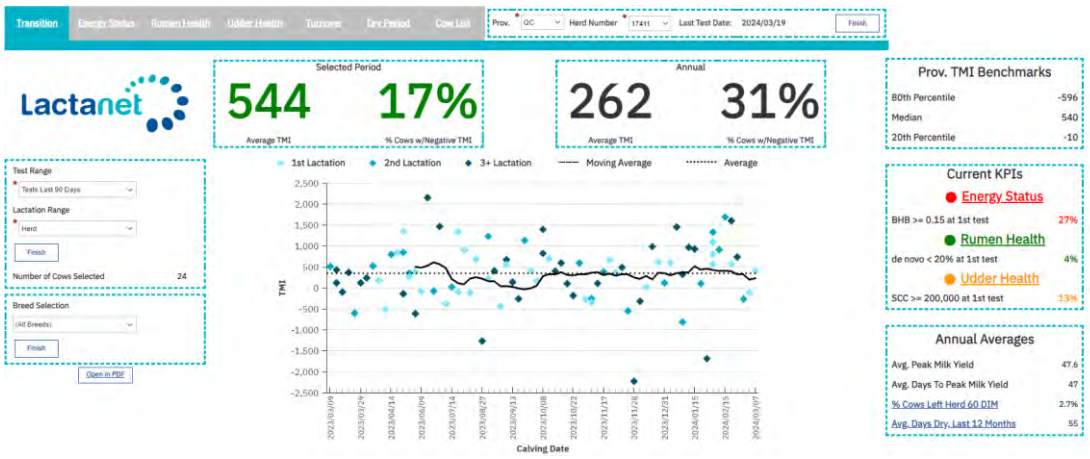

Figure 4. Main page of the Transition Management Index dashboard created by Lactanet Canada.

Conclusion

In conclusion, the Transition Management Index serves as an invaluable objective tool to assess the transition period practices on farm. Its correlation with production, reproduction, and health parameters indicates that the transition success is associated with herd performance and profitability. The use of the TMI and its dashboard will guide producers and advisors to better assess the farm operation, identify opportunities for improvement, and facilitate informed decision-making processes.

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