Characterization of estrus detection, conception and pregnancy risk of Holstein cattle from the central area of Chile

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Abstract

The objectives were to characterize the estrus detection risk (HDR), conception risk (CR), and pregnancy rate (PR) of postpartum (pp) Holstein cattle from the central area of Chile. The study used records of 2269 lactations from six dairy farms in central Chile (Mediterranean-type climate) during 2004. Three 21-d periods for estrus detection were considered (50–70, 71–91, and 92–112 d pp). Estrus detection risk, CR, and PR at the first, second, and third periods were analyzed by logistic regression, whereas overall PR at the end of the 63-d study (112 d pp) was assessed with survival analysis. The overall HDR was 51.1%. The HDR, CR, and PR were 48.4, 42.2, and 17.3%, respectively, during the first period; 52.8, 41.8, and 20.5% during the second period; and 52.9, 39.2, and 19.7% during the third period. The HDR was lower during Period 1 than during Periods 2 and 3 ($P \leq 0.05$). Conception risks were not different among periods ($P > 0.05$); however, PR was lower during Period 1 than during Periods 2 and 3 ($P \leq 0.05$). Overall PR over time differed among parities, but was not significantly different among seasons. There were no significant interactions among parity, season and herd for HDR, CR and PR for the three 21-d periods. Parity 1 had higher CR and PR than Parity 2 and 3+ during Period 3. Overall, survival curves for the risk of non-pregnancy among parities (1, 2, 3 or greater) were different over time ($P \leq 0.05$). Cows of Parity 1 became pregnant earlier than cows of Parity 2, and Parity 3 or greater. Survival curves for the risk of non-pregnancy among seasons (summer, fall, winter, and spring) were not different over time ($P > 0.05$).

Keywords: Estrus detection risk; Conception risk; Pregnancy rate; Dairy cattle; Chile

1. Introduction

The central area of Chile is an agricultural region located at latitude 32.0S to 35.3S and longitude 71.1W to 71.5W. It has a Mediterranean-type climate, with a minimum and maximum ambient temperature of 3 and 32 °C, respectively, and a mean rainfall of 400 mm/y (0 mm in January and 80 mm in July) [1]. Chilean cattle are represented by two typical groups. One is the small-family agriculturist group, with 50% of the country's livestock and characterized by low-technology level and extensive management. The other is the commercial group, characterized by more advanced technology and intensive management. In the latter group, the Holstein breed is the most common in central Chile, since genetics from Canada and the USA have been introduced gradually during the last 30 y [2,3]. However, the cattle population of this area represents only 20% of the total cattle population of the country, and the average size of the dairy herd is 100 cows [4],

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with an average mature equivalent 305 d milk production of 9500 kg [4,5].

Commercial, intensively managed dairy herds in the central area of Chile use AI exclusively; however, due to the small herd size, estrus detection is preferred and timed AI programs are rarely used [5]. Consequently, reproductive efficiency depends entirely on estrus detection strategies.

An indicator of reproductive efficiency in dairy herds is the pregnancy rate (PR) in a 21-d period, defined as the number of pregnant cows that became pregnant, divided by the number eligible to be bred during a 21-d interval. This measure depends on estrus detection efficiency and conception rate (CR) [6]. Pregnancy rate is typically calculated by computer software programs. Although it is not essential to calculate heat detection rate (HDR) to measure PR, it may be useful to quantify HDR to investigate reproductive management.

In the absence of reports regarding estrus detection, conception, and pregnancy risk in Chilean dairy cattle, base-line information is needed to enable producers to gauge reproductive performance in their herd and to make reproductive management decisions. In addition, standardized calculations can be used for comparative purposes within Chile and between similar systems and geographical areas of the world. The objective of this study was to characterize the risk for estrus detection, conception, and pregnancy rates during early lactation in Holstein cattle from the Central area of Chile during 2004.

2. Material and methods

2.1. Farms

The study was conducted in the central area of Chile. Records from six commercial dairy herds located within 80 km of Santiago, Chile, were obtained for a period of 1 y. Descriptive information for the six herds in the study is shown (Table 1). All herds had similar management, typical of the central area of Chile. Cows were housed under confinement, milked three times a day, and fed based on milk production (high, medium, low), and parity (primiparous or multiparous) to meet or exceed NRC recommendations [7]. The diet consisted of alfalfa hay, corn silage and a commercial concentrate. The herds were selected according to the willingness of owners to participate. These herds can be considered as representative of the commercial intensive stratum of the central area of Chile.

Reproductive management consisted of a voluntary waiting period (VWP) of 50 d, periodic visual estrus detection, and AI following detection of estrus. Periodic visual estrus detection consisted of detection by a designated employee at 06:00 for 30 min, and at 18:00 for another 30 min, plus informal observations by employees when cows were brought to the milking parlor. Artificial insemination of cows in estrus was conducted by trained farm employees, with the number of inseminators varying among farms (Table 1). Cows not detected in estrus after insemination had a pregnancy examination (transrectal palpation) approximately 45 d after breeding.

Pregnant cows were dried-off either at 7 months of pregnancy, or when cows were more than 450 d in lactation, and milk production was <10 kg/d. From dry-off to 21 d before expected parturition, cows were housed in dry-lots. Thereafter, they were moved to a prepartum lot. When cows showed signs of imminent parturition (tail ligament relaxation, presence of colostrum in mammary gland), they were moved to an individual stall in a maternity barn. Calves were separated from their dams as soon as possible after parturition. Approximately 24 h after calving, cows were routinely examined for retained fetal membranes, lacerations of the internal and external genital tract, and the presence of udder edema or clinical mastitis. Between 24 and 38 d pp, reproductive tract status was assessed with vaginoscopy and transrectal palpation. All farms used a computerized record keeping system; therefore, data were handled consistently.

2.2. Study design

The study was conducted using records of cows between December 01, 2003 and November 30, 2004; the data set consisted of 2269 lactations. This was an observational study, in which reproductive records from dairy cows managed under Chilean commercial and intensive management settings were analyzed. Information regarding cow identification, lactation number, farm, calving date, cumulative milk yield to 100 d, date of estrus detection, and date of AI were recorded. Each dairy had its own record system and one of the authors obtained the information for each lactation, verifying accuracy and consistency of the data. A 63-d interval of estrus detection after the VWP was established; therefore, three potential estrous cycles of 21 d for estrus detection were considered (50–70 d pp; 71–91 d pp; 92–112 d pp). The length of study period (63 d) was based on a previous study of Chilean dairies, with a calving to first breeding interval of approximately 90 d [5]. In addition, three potential estrous cycle periods were considered sufficient to evaluate estrus detection,

Table 1
Heat detection risk, conception risk, pregnancy risk, and descriptive statistics of six studied Holstein herds from the Central area of Chile, using visual estrus detection

Herd	Heat detection risk (%) (*n*)	Conception risk (%) (*n*)	Pregnancy risk (%) (*n*)
Period 1 (50–70 d pp)			
1	60.5[a] (555)	52.0[a] (248)	23.2 [a] (555)
2	35.6[b] (391)	45.0[a] (131)	15.1[a] (391)
3	54.1[c] (266)	45.9[a] (133)	22.9[a] (266)
4	36.3[bc] (179)	24.1[b] (58)	7.8[b] (179)
5	40.8[bc] (588)	30.7[b] (189)	9.9[b] (588)
6	60.2[a] (289)	42.0[b] (169)	24.6[a] (289)
Period 2 (71–91 d pp)			
1	56.8[a] (426)	53.8[a] (199)	25.1[a] (426)
2	40.1[b] (332)	48.1[a] (129)	18.7[a] (332)
3	53.7[a] (205)	42.1[a] (107)	22.0[a] (205)
4	37.0[b] (165)	34.5[b] (58)	12.1[b] (165)
5	55.5[a] (530)	31.9[b] (279)	16.8[b] (529)
6	68.8[a] (218)	41.5[a] (147)	28.0[a] (218)
Period 3 (92–112 d pp)			
1	58.0[a] (319)	48.3[a] (172)	26.0[a] (319)
2	48.2[b] (270)	33.3[b] (126)	15.6[b] (270)
3	61.3[a] (160)	36.6[b] (93)	21.3[a] (160)
4	47.6[b] (145)	41.8[a] (67)	19.3[a] (145)
5	50.2[a] (440)	33.3[b] (210)	15.9[b] (440)
6	54.8[a] (157)	44.6[a] (83)	23.6[a] (157)

Mature equivalent milk yield (corrected to 305 d and milked twice daily) was: Herd 1: 12,223 kg; Herd 2: 10,828; Herd 3: 11,696; Herd 4: 12,534; Herd 5: 11,572; and Herd 6: 13,464. No. inseminators: Herd 1: 3; Herd 2: 2; Herd 3: 3; Herd 4: 1; Herd 5: 4; and Herd 6: 2. [a–c]Within a column and period, risks without a common letter differed ($P < 0.05$).

conception, and pregnancy risk. Data were not used from cows that experienced abortion (1.8% of pregnancies), had an extremely difficult calving (fetotomy, cesarean section; 0.55% of deliveries), or were bred before 50 d pp and became pregnant (0.18% of services).

Estrus detection, pregnancy and conception probabilities were studied within the three 21-d periods after the VWP. Because they were not evaluated after the 63-d interval and were not expressed per unit of time, the term ''risk'' instead of ''rate'' at the first, second and third eligible periods, was the appropriate terminology. Estrus detection risk (HDR), the probability of detection of estrus during a 21-d period, was calculated using the number of cows detected in estrus during the 21-d period, divided by the number of cows eligible to be detected in estrus during that period, multiplied by 100. Conception risk at first, second, and third insemination was defined as the probability of diagnosis of pregnancy following each insemination. Conception risk at each period was calculated as the number of cows diagnosed pregnant to AI that occurred during that period, divided by the number of cows inseminated during that period, multiplied by 100. Pregnancy risk at the first, second and third periods was defined as the probability of pregnancy per cow eligible to be inseminated within that particular period. Pregnancy risk was calculated as the number of cows diagnosed pregnant to AI in that period, divided by the number of cows eligible to be bred in that period, multiplied by 100. Finally, the probability of pregnancy at the end of the three eligible periods (pregnancy rate) was also calculated; it was defined as the total number of periods eligible for breeding during the entire three 21-d periods under study, multiplied by 100. For this calculation, censored animals (sick, culled, dead, missed record, etc.) during the entire study period were considered in the statistical evaluation of pregnancy rate (survival analysis).

2.3. Statistical analysis

Estrus detection risk, CR and PR at each period were analyzed by logistic regression models, through a backward elimination procedure [8]. Goodness of fit of data was determined using the deviance value of the models. Explanatory variables considered for all models were farm (1–6); parity (1, 2, 3 or greater), projected milk yield (kg) to 100 d pp (based on the first three test-days); season (summer, fall, winter, spring), and potential two-way interactions. Summer was

Table 2
Descriptive statistics for the probability of estrus detection, conception, and pregnancy across three 21-d periods (starting at 50 d pp) in Holstein cattle in central Chile

Item	Heat detection risk (%) (*n*)	Conception risk (%) (*n*)	Pregnancy risk (%) (*n*)
Period 1 (50–70 d pp)	48.4%[a] (2268)	42.2%[a] (928)	17.3%[a] (392)
Period 2 (71–91 d pp)	52.8%[b] (1876)	41.8%[a] (920)	20.5%[b] (384)
Period 3 (92–112 d pp)	52.9%[b] (1491)	39.2%[a] (751)	19.7%[b] (294)

[a,b]Within a column, risks without a common letter differed ($P \leq 0.05$).

defined as December 01 to February 28, fall as March 01 to May 31, winter as June 01 to August 31, and spring as September 01 to November 30. Estrus detection risk, CR and PR were compared among Periods 1, 2, and 3, correcting for parity, milk yield, herd, and season.

Overall pregnancy rate at the end of the 63-d study (112 d pp) was analyzed by survival analysis. The effects of parity and season on PR were also measured by survival analysis. Statistical analysis was conducted with SAS 9.01 [8], using the LOGISTIC procedure (HDR, CR, and PR), as well as the PHREG procedure (survival curves for pregnancy rate).

3. Results

Descriptive statistics for HDR, CR, and PR by period are shown (Table 2). During the entire period of the study (50–112 d pp), 2877 estrus periods, out of 5635 eligible potential cycles, were detected, corresponding to an overall HDR of 51.1%. During the first period (50–70 d pp), 2268 cows were eligible for estrus detection. Out of this total, 1098 cows were detected in estrus (48.4%), but only 928 were inseminated and 392 became pregnant; therefore, the CR was 42.2% (392/928), and the PR was 17.3% (392/2268). During the second period (71–91 d pp), 1876 cows were eligible for estrus detection. Out of this total, 990 cows were detected in estrus (52.8%), but only 920 were inseminated and 384 became pregnant; therefore, the CR was 41.8% (384/920) and the PR was 20.5% (384/1876). During the third period (92–112 d pp), 1491 cows were eligible for estrus detection. Out of this total, 789 cows were detected in estrus (52.9%), but only 751 were inseminated and 294 became pregnant; therefore, the CR was 39.2% (294/751) and the PR was 19.7% (294/1491).

Table 3
Logistic regression model of the probability of detection of estrus correcting for milk yield, parity, season and herd across three 21-d periods (starting at 50 d pp) in Holstein cattle in central Chile

Variable	Level	OR[a]	95% CI OR[b]	Probability
Period[c]	1 vs 3	0.795	0.696–0.908	0.0005
	2 vs 3	0.975	0.849–1.12	
Milk yield[d]	Per 100 kg milk	1.005	0.99–1.01	0.22
Parity[e]	1 vs 3	1.101	0.965–1.257	0.35
	2 vs 3	1.05	0.91–1.212	
Season[f]	1 vs 4	1.125	0.957–1.322	0.0007
	2 vs 4	0.827	0.711–0.963	
	3 vs 4	0.937	0.801–1.095	
Herd	1 vs 6	0.881	0.724–1.072	<0.0001
	2 vs 6	0.421	0.339–0.523	
	3 vs 6	0.799	0.636–1.005	
	4 vs 6	0.40	0.313–0.51	
	5 vs 6	0.581	0.477–0.706	

[a] OR: odds ratio.
[b] 95% confidence interval odds ratio.
[c] Period 1:50–70 d pp, Period 2: 71–91 d pp, Period 3: 92–112 d pp.
[d] Projected milk yield to 100 d.
[e] Parity 1, 2, 3 or greater.
[f] 1: summer, 2: fall, 3: winter, 4: spring.

In the logistic regression models for HDR, correcting for milk production, herd, parity and season, in Period 1 (50–70 d pp), cows had a lower risk to be detected in estrus than cows in Periods 2 and 3 ($P \leq 0.05$); however, in Period 2, cows had similar risk to be detected in estrus to those in Period 3 ($P > 0.05$; Table 3). In the logistic regression models for CR, correcting for milk production, herd, parity and season, CR were not different among the three periods in study ($P > 0.05$; Table 4). In the logistic regression model for PR, correcting for milk production, herd, parity and season, in Period 1 (50–70 d pp), cows had a lower risk for pregnancy than cows in Periods 2 and 3 ($P \leq 0.05$); however, cows in Period 2 had similar risk of pregnancy as those in Period 3 ($P > 0.05$; Table 5).

There were no significant interactions among parity, season and herd for HDR, CR and PR for the three 21-d periods and the HDR was similar among parities for each 21-d period. In addition, Parity 1 had higher CR and PR than Parity 2 and 3+ during Period 3. Herds 1, 3, and 6 had the highest PR, and Herds 2, 4, and 5 had the lowest PR within each 21-d period. Summer had the lowest PR and spring the highest PR within each period 21-d period, but the differences were not significant. Overall, survival curves for the risk of non-pregnancy among parities (1, 2, 3 or greater) were different over

Table 4
Logistic regression model of the probability of conception, correcting for milk yield, parity, season and herd across three 21-d periods (starting at 50 d pp) in Holstein cattle in central Chile

Variable	Level	OR[a]	95% CI OR[b]	Probability
Period[c]	1 vs 3	1.099	0.899–1.343	0.335
	2 vs 3	1.128	0.923–1.378	
Milk yield[d]	Per 100 kg milk	0.996	0.984–1.008	0.50
Parity[e]	1 vs 3	1.323	1.082–1.617	0.0035
	2 vs 3	1.003	0.809–1.243	
Season[f]	1 vs 4	0.829	0.653–1.051	0.13
	2 vs 4	0.800	0.637–1.005	
	3 vs 4	0.978	0.776–1.233	
Herd	1 vs 6	1.352	1.040–1.758	< 0.0001
	2 vs 6	0.984	0.720–1.346	
	3 vs 6	0.959	0.704–1.306	
	4 vs 6	0.717	0.492–1.045	
	5 vs 6	0.625	0.474–0.823	

[a] OR: odds ratio.
[b] 95% confidence interval odds ratio.
[c] Period 1:50–70 d pp, Period 2: 71–91 d pp, Period 3: 92–112 d pp.
[d] projected milk yield to 100 d.
[e] Parity 1, 2, 3 or greater.
[f] 1: summer, 2: fall, 3: winter, 4: spring.

Table 5
Logistic regression model of the probability of pregnancy correcting for milk yield, parity, season and herd across three 21-d periods (starting at 50 d pp) in Holstein cattle in central Chile

Variable	Level	OR[a]	95% CI OR[b]	Probability
Period[c]	1 vs 3	0.805	0.679–0.954	0.005
	2 vs 3	1.024	0.862–1.216	
Milk yield[d]	Per 100 kg milk	1.003	0.993–1.013	0.591
Parity[e]	1 vs 3	1.259	1.060–1.495	0.02
	2 vs 3	1.048	0.871–1.263	
Season[f]	1 vs 4	0.956	0.782–1.17	0.029
	2 vs 4	0.778	0.643–0.942	
	3 vs 4	0.986	0.814–1.195	
Herd	1 vs 6	0.919	0.736–1.147	<0.0001
	2 vs 6	0.578	0.443–0.753	
	3 vs 6	0.846	0.648–1.105	
	4 vs 6	0.426	0.308–0.589	
	5 vs 6	0.472	0.372–0.600	

[a] OR: odds ratio.
[b] 95% confidence interval odds ratio.
[c] Period 1:50–70 d pp, Period 2: 71–91 d pp, Period 3: 92–112 d pp.
[d] projected milk yield to 100 d.
[e] Parity 1, 2, 3 or greater.
[f] 1: summer, 2: fall, 3: winter, 4: spring.

time ($P \leq 0.05$; Fig. 1); therefore, cows of Parity 1 became pregnant earlier than cows of Parity 2, and Parity 3 or greater. Survival curves for the risk of non-pregnancy among seasons (summer, fall, winter, spring) were not different over time ($P > 0.05$); therefore, overall pregnancy rate over time was similar among cows bred in summer, fall, winter, or spring.

4. Discussion

The present study analyzed 2269 lactations from six commercial herds in central Chile. We inferred that the management of these herds was better than the national average for Chilean dairies.

The overall HDR was 51.1%; this was in the upper range of estrus detection efficiency of ≤50% reported by dairies in the USA [9–12] and 48% for dairies in Canada [13]. Other studies have reported values that seemed lower than those of the present study. For instance, the mean efficiency of detection of estrus for 4550 herds processed at the Raleigh Dairy Record Processing Center for the year of 1992 was 38% [14] and the mean HDR for dairy farms in Portugal (1980–1998) was 38.1% [15]. In the southeast part of the USA, a HDR of 41.5% for 1997 and 1999 was reported [11]. Conversely, in a study conducted in Wisconsin (USA), a HDR of 63.8% between 54 and 80 d pp was reported; however, a Kamar device activation system was used as an aid. The HDR was slightly (albeit significantly) lower in Period 1 (48.4%) than in Periods 2 (52.8%) and 3 (52.9%). In contrast, in a study comparing three estrous detection systems in dairy herds during summer in North Carolina, cows detected in estrus before 79 d pp had a significantly higher number of standing events when compared to cows detected after 80 d pp [16], which would be expected to make detection of estrus more likely in the early time frame. In the same study, visual observation had the highest HDR (49.3%), in contrast with an electronic device that assessed walking

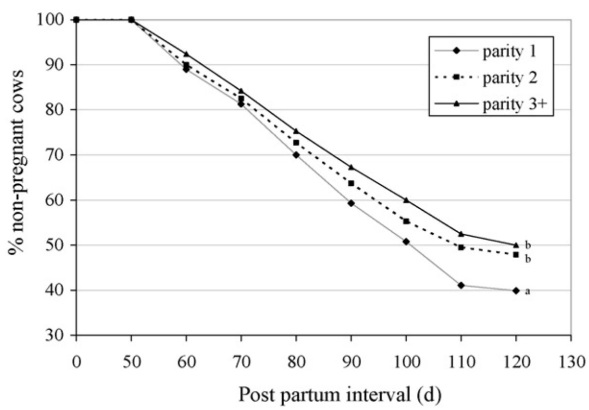

Fig. 1. Survival curves for the risk of non-pregnancy among parities (1, 2, 3 or greater) in Holstein cows from central Chile between 50 and 112 d pp. [a,b]Curves without a common letter differed ($P \leq 0.05$).

activity of the cow (ALPRO system; 37.2%) and a radio telemetric system recording the pressure on the rump area when a cow was mounted (HeatWatch system) (48.0%) [16]; however precision and accuracy of estrus detection were issues when it was detected visually, as in the present study. Based on the analysis of HDR within periods and parity, there were no differences in the proportion of cows detected in estrus. In the study by Peralta et al. [16], mean standing events in cows detected in estrus by the HeatWatch system were significantly higher for cows of first lactation, compared with cows of second and third lactation. However, in the study of Rocha et al. [15], there was no difference in HDR between Parity 1 and 2 (47.5 vs 50.6%, respectively), but HDR for Parity 3 and 4 was higher than for Parity 1 and 2 (54.7 and 60.5%). These apparent inconsistencies may be explained because expression of estrus and its detection are affected by several factors, including milk production, nutrition, environment, metabolic diseases, and lameness, all of which are influenced by management. These variables may be surrogate measures of management, or they may confound other associations with reproduction if they are not taken into account [9,17,18].

The HDR was affected by season within periods, and in general, fall had a lower HDR than the other three seasons. In central Chile, fall is characterized by changes in the weather, with the beginning of rainy cool season, and formation of mud [1]. Concurrently, herd management changed, especially feed (decreased quality of hay and silage), and housing conditions, which may have negatively affected HDR and reproductive performance of herds. Overall, CR was not different among the three periods ($P > 0.05$) in the present study; however, when the information was analyzed within parity, cows of second and third or greater lactations had a lower CR than first-lactation cows in Periods 2 and 3. These differences in CR among parities may account for some of the improved PR over time for Parity 1 cows. Similarly, in other studies in the USA and Europe, first-lactation cows have similar or better CR compared with multiparous lactating cows [19,20]; however, it contrasts with the results of the study of Melendez and Pinedo [5] for Holstein cows in south-central Chile, and the study of Rocha et al. [15] in Portugal, in which first-lactation cows had a lower CR at first service ($P > 0.05$) than cows with second or third and greater lactations. Apparent differences in reproductive performance in first-parity animals may be confounded by social and nutritional management of these animals before and during their first lactation.

Conception risk within season was lower during summer within the third period (92–112 d pp) than during the rest of the seasons. This was not surprising, because summer in the central area of Chile is characterized by temperatures >32 °C. The negative effect of heat stress on conception in dairy cattle, especially from the day of service to 6 d after breeding, is well established [21,22].

Overall pregnancy rate was statistically different within parity, but not within season. This rate is easily calculated through computer programs such as Dairy-COMP-305 (Valley Agricultural Software, Tulare, CA, USA) and PCDART (Dairy Records Management Systems, Raleigh, NC, USA). These programs estimate the pregnancy rate in a straightforward way (without considering the HDR), in part because either many farms used timed AI, or because HDR is intrinsically considered in the computing calculation, without being reported. Nevertheless, other countries such as Chile use local programs to analyze reproductive data, in which the significance of HDR is extremely important to evaluate the reproductive efficiency of dairy farms. Indeed, two studies have reported that HDR was the major determinant of non-pregnant days and reproductive performance of dairy cows [23,24].

In conclusion, Holstein cattle in central Chile had an overall HDR of approximately 50%, which was slightly lower between 50 and 70 d pp than 71–112 d pp. There were no differences among parities, but HDR was slightly lower during fall than the rest of the seasons. Overall, CR was similar among periods, but it was higher in Parity 1 than in older animals, and tended to be lower during summer. Consequently, PR was lower between 50 and 70 d pp than between 71 and 112 d pp, higher in Parity 1 versus Parity 2 and greater lactations, and tended to be lower during summer and fall than in winter and spring.

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