Monitoring reproductive performance of small dairy herds in veterinary practice

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Abstract

A descriptive field study involving 87 herds (3608 cows) in two veterinary practices was conducted to compute mean values for a panel of reproductive herd parameters. A method of monitoring herds and identifying those herds experiencing reproductive inefficiency is reported.

When comparing the means of herd indices for both practices, only the means for the index "percent in heat by 60 days" were significantly different. Overall, 20 herds were found to have at least one herd index which was significantly different from the mean for all herds. Fourteen herds were found to have significant reproductive inefficiency. If the index "percent problem cows" had not been used, 29% of the herds with reproductive inefficiency would not have been identified. Our study suggests that it is useful to compare reproductive indices among herds, practices, and regions using a veterinary office microcomputer.

Résumé

Surveillance du rendement en reproduction des troupeaux laitiers de petite envergure en pratique vétérinaire

Une étude descriptive dans le champs regroupant 87 troupeaux (3608 vaches), répartis dans deux pratiques vétérinaires, a été effectuée pour calculer les valeurs moyennes d'une liste de paramètres établis à partir de troupeaux en reproduction. Les auteurs présentent une méthode de surveillance et d'identification des troupeaux ayant un taux inadéquat de reproduction. En comparant les moyennes des indices des troupeaux pour les deux pratiques vétérinaires, seulement les moyennes de l'indice "pourcentage en chaleur à 60 jours" démontrent une différence significative. De manière générale, 20 troupeaux ont présenté au moins un paramètre différent de façon significative de la moyenne de tous les troupeaux. Quatorze troupeaux ont démontré de façon significative un taux adéquat de reproduction. Si l'indice "pourcentage des vaches présentant des problèmes" n'avait pas été utilisé, 29 % des troupeaux ayant un taux insuffisant de reproduction n'auraient pas été identifiés. À la lumière de cette étude, les auteurs suggèrent qu'il serait avantageux de comparer les indices de reproduction entre les troupeaux, les cliniques vétérinaires et les régions en utilisant un microordinateur en pratique vétérinaire.

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Introduction

While reproductive work is the mainstay of dairy practice (1), computerized monitoring of herd reproductive performance remains a challenge (2). The usefulness of indices such as "days to conception", "calving interval", and "conception rate" has been well documented (3–12). Approaches to diagnosing dairy herd infertility in both large and small herds have been published (3,13,14).

Various authors have discussed the fact that reproductive indices may take into consideration only part of the total herd population or may refer to current or historical time frames (4,10,15,16). "Days to conception" is a relatively current measure of reproductive performance of pregnant cows, while "calving interval" is a historical measure of the performance of both open and pregnant cows with at least two calvings. The "reproductive cull rate" measures historical reproductive failure. "Herd reproductive status index" measures success and accounts for failure. However, the latter is not useful for application in dairy herds with fewer than 200 cows (17).

Some authors have defined the index "percent of the herd open after 150 days in milk" (4,18). Fetrow *et al* (12) define "percent problem cows" as cows open more than 100 days. Harmon and McCloskey (15) define "infertility rate" as cows open at least 150 days divided by cows at least 150 days in milk. Braun (19) defines "percent problem cows" as the number of cows in the breeding herd open over 100 days in milk divided by the total cows in the herd.

Shultz (8) has devised a scheme to compute calving intervals while categorizing animals as problem cows. Others (10,18) have described "percent of cows inseminated by 90 days". Recently, practitioners working with smaller dairy herds have devised the "JMR index" to measure current herd reproductive performance (20,21).

Both target and interference values for indices have been proposed (3,5), and several computer programs are available for calculation of reproductive indices (22). Williamson (23,24) reported mean reproductive indices for 21 herds using a herd health software program on a university mainframe.

The first objective of the descriptive field study reported herein was to define reproductive parameters suitable for monitoring small dairy herds and computing baseline values using a microcomputer in a veterinary office. The second objective was to report the use of an index, "percent problem cows", as a measure of current reproductive failure in small dairy herds.

Materials and methods

Data collection and record keeping

All herds receiving reproductive health services from two participating veterinary practices were selected for this study. These initial 106 herds were monitored for at least one year, ending in 1989. Nineteen herds were excluded because of incomplete data.

Of the 87 herds remaining in the study, 30 herds were in central Wisconsin and the other 57 herds were in western Quebec. The Vetcheck software program (Infovet Inc., Lachute, Quebec) was used for the study (25). With this software, we generated a reproductive performance summary sheet, a worksheet, and an open cow report which were used at every herd visit to collect data and monitor reproductive performance. At every herd visit, the reproductive performance summary report compared the herd's current reproductive indices to the herd's objectives as well as to the practice means (26,27).

Table 1. Comparison of four problem cow rates in two geographically distinct dairy cow populations

	Wisconsin	Quebec
% cows > 90 days open, not bred	3.8	3.1
% cows > 150 days open, bred, not pregnant	8.1	7.4
% repeat breeder	6.4	5.0
% not calved, not pregnant within last year	0.74	0.67

All comparisons between geographic regions are not significantly different at $p < 0.05$

Statistical methods

At the end of the one-year study period, a reproductive summary report, a worksheet, and an open cow report were generated for each of the herds as of the day following the last herd visit. These data were loaded onto a Lotus spreadsheet (Lotus Development Corp., Cambridge, Massachusetts, USA). Lotus functions were used to calculate sums, means, standard deviations, ranges, and distributions. Formulas (28) to calculate the significance of the difference between two means (SEM) and the significance of the difference between proportions (SEM) were also used on the Lotus spreadsheet.

For the rates in Table 1, the numerators were the number of open cows qualifying in both the Wisconsin and Quebec populations while the denominators were the total cow populations of the respective regions. The mean reproductive herd parameters (Table 2) were calculated by adding the respective herd parameters and dividing by the number of herds.

It has been recommended to report SD for individual herd indices (3,29,30). Because of small herd sizes, we did not find it useful to report the SD of an individual herd index (31). We chose to calculate the mean herd indices for all herds and report SD. To show the number of cows eligible for the numerators and the denominators of the different herd parameters, a distribution of cows according to stage of reproduction is provided (Table 3).

Our reproductive summary reports were rolling annual reports, as of herd visit date, at whatever interval these occurred. The American Association of Bovine Practitioners (AABP) has recommended reports for two to six month periods when evaluating small herds (29).

Defining parameters

Harmon and McCloskey (15) reported that summary data such as reproductive indices may be calculated in a variety of ways. Time frames, populations, and specific criteria may differ from one method of calculation to another or one processing center to another (29,30).

In our study, herd parameters which were not proportions were calculated by summing individual cow values and dividing by the number of values summed. For herd parameters that were proportions, calculations showed the number of cows qualifying as a numerator and used current herd size as the denominator. The following are the definitions used in computing herd reproductive parameters.

"Services per conception" was defined as the total number of services per total number of conceptions occurring within the past 12 months. This was similar to AABP's "services per pregnancy, pregnant cows, past year" (29), with the exception that we did not include removed cows.

"Overall conception rate" was defined as the total number of cows conceiving divided by the total number of services to cows conceiving.

"First service conceptions" was defined as the number of cows conceiving on a single service within the last year over total number of cows conceiving within the same period.

"Days to first heat" was defined as the number of days from calving to first heat.

"Percent in heat by 60 days" was defined as the percentage of cows included in the "days until first heat" that showed a heat on or before 60 days.

"Days to first breeding" was defined as the number of days from calving to first breeding.

"Days to conception" was defined as the number of days from calving to conception. In agreement with Gaines (4), we chose to report "days to conception", excluding both open and removed cows rather than "projected minimum average days open" as recommended by the AABP (29). The AABP recommendation is a "best estimate". It assumes cows open with a breeding date are pregnant as of the last breeding. Open cows past the voluntary waiting period are assumed bred and pregnant within 10 days of the report date. We preferred diagnosing pregnancy rather than assuming cows pregnant.

"Actual calving interval" was calculated as the average number of months between calvings for cows with at least two calvings and currently in the herd. It is similar to the AABP definition of "past year calving interval" (29), but differs in that we excluded removed cows. Our definition is in agreement with that proposed by Gaines (4).

"Projected calving interval" added 280 days to "days to conception" and divided by 30.34. This was different from the AABP recommendations (29) as it was not based on "projected minimum average days open", but rather on "days to conception". "Projected calving interval" was used for a summary economic

Table 2. Comparison of mean herd parameters between two veterinary practices

	Wisconsin (30 herds) $\bar{X}$	SD	Quebec (57 herds) $\bar{X}$	SD	Combined (87 herds) $\bar{X}$	SD	Range
Herd size (cows)	40.7	18.2	41.9	21.9	41.6	14.9	21-112
Known pregnant (%)	57.6	9.7	54.8	8.1	55.8	8.8	36-81
First service conceptions (%)	48.7	14.4	51.7	13.4	50.6	13.8	21-91
Overall conception rate (%)	53.5	11.7	55.1	10.6	54.6	11.0	33-92
Services per conception	1.94	0.38	1.87	0.37	1.89	0.38	1.1-3.0
Days to first heat	69.6	15.1	73.6	14.3	70.0	14.7	39-135
Percent in heat by 60 days	40.6	15.3	32.2	17.1[a]	35.0	17.0	9-76
Days to first breeding	82.3	13.5	80.8	12.1	81.0	12.6	60-135
Heat detection rate (%)	64.8	33.1	52.4	17.3	56.6	24.7	33-231
Days to conception	117.8	17.1	117.6	16.5	118.0	16.7	78-151
Actual calving interval (mo)	12.9	0.75	13.0	0.62	13.0	0.67	11.5-15.2
Projected calving interval (mo)	13.1	0.55	13.1	0.54	13.1	0.54	11.8-14.2
Percent problem cows	11.9	6.2	10.3	5.8	10.8	6.0	0-26
Reproductive cull rate (%)	9.0	6.9	9.1	7.4	9.1	7.3	0-38

[a]Significantly different, $p < 0.05$

analysis of predicted reproductive performance. We assumed it was in our best interest to predict a probable rather than a best case scenario.

"Reproductive cull rate" was calculated as the number of cows culled within the last year with reproduction listed as one of two possible culling reasons divided by current herd size. The AABP recommends an average herd inventory as the denominator (29).

"Heat detection rate" was defined as heats or breedings reported over heats biologically expected. Heats and/or breedings within four days of each other were considered one heat. The calculation was made from the time of first breeding or first reported heat, to the time of the last breeding before conception. This calculation was different when compared to the AABP recommendations for "percent of possible estruses detected" (29). Our definition did not require the collection of a voluntary waiting period or the recording of the use of prostaglandin as those data were difficult to collect in most herds. Using our definition, a cow must first have been reported in heat or bred before it was included. This was done because collection of prebreeding heat data was difficult with many managers (23).

"Percent problem cows" was defined as the sum of cows not bred and more than 90 days open and cows bred and more than 150 days open but not diagnosed pregnant, divided by the total number of cows currently in the herd.

"Repeat breeders" were defined as cows bred three times or more and not known pregnant.

"Not calved nor pregnant" was defined as cows that had not calved, nor been known pregnant within the last year.

Results

There were 3608 cows in 87 herds at the end of the study. Thirty herds in Wisconsin had a total of 1222 cows while 57 herds in Quebec had 2386 cows. Fifty-seven percent of the Wisconsin cows and 56% of the Quebec cows were pregnant at the end of the study.

Table 1 shows the percentage of cows greater than 90 days open and not bred, cows greater than 150 days open that were bred but not known pregnant, repeat breeders, and cows not calved nor known pregnant within the last year in both the Wisconsin and Quebec populations. Rates for the total cow population were 3.3, 7.6, 5.4, and 0.69%, respectively.

Table 2 shows the means for the reproductive parameters of the 87 herds. When herd parameters were compared between practices only "percent in heat by 60 days" was significantly different.

Table 3 presents 20 herds (23% of the 87 herds) which had at least one reproductive parameter that was significantly different from the mean. Fourteen herds (16%) had at least one parameter indicating failure or inefficiency that was significantly different from the mean parameter of all 87 herds. Nine herds (A-I) had either historical (A-E) or current (F-I) reproductive failure. Of the 14 herds (A-I, P-T) with significant failure or inefficiency, five herds (A-E) were identified only because we were measuring "reproductive cull rate". Four herds were identified only because we were measuring "percent problem cows". Three herds (R-T) were identified only because of long "actual calving interval". Only two herds (P,Q) had poor conception rates while three herds (M-O) had significantly superior conception rates. Three herds (J,L,N) were different in that a first heat was reported significantly later. In one herd (N), "days to first breeding" was significantly longer. One herd (K) had significantly superior reporting of prebreeding heats while two herds (M,N) had a high "heat detection rate".

Discussion

Have we been emphasizing the appropriate measures of reproductive performance? "Days to conception", "actual calving interval", and conception rates are key indices generally used to assess reproductive performance. In our study the key indices detected only 36% of the problem herds. The rest of the herds were only detected because we were measuring "reproductive cull

Table 3. Panels of herd parameters for 20 herds showing significantly different herd reproductive efficiency

Herd	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
Herd size (cows)	24	29	25	29	32	62	23	44	48	30	32	71	38	34	35	27	30	74	47	53
Cows known pregnant	15	16	9	15	22	28	12	21	21	17	15	33	26	14	15	13	22	34	19	30
Open cows	9	13	16	14	9	34	11	21	26	13	16	37	12	19	19	12	8	39	27	23
NCNP[a]	0	0	0	0	1	0	0	2	1	0	1	1	0	1	1	2	0	1	1	0
1st service conceptions	40	39	73	62	55	23	55	60	33	70	56	72	83*	91*	80*	25	21*	39	37	43
Services per conception	2.1	2.3	1.4	1.5	1.8	2.4	1.6	1.5	2.0	1.4	1.6	1.5	1.2*	1.1*	1.3	2.8*	3.0*	2.5	2.4	2.0
Days to 1st heat	68	63	86	74	75	74	89	89	88	101*	39*	105*	81	135**	74	59	47	81	53	76
% in heat at 60 days	38	43	13	30	33	17	27	9	17	12	76*	15	13	12	31	45	67	24	67	20
Days to 1st breeding	80	81	88	74	80	76	90	98	99	105	70	106	85	135**	80	72	61	83	84	83
Heat detection rate	46	59	45	43	44	46	56	41	59	33	35	45	147**	231**	33	48	60	56	45	57
Days to conception	131	128	107	99	119	140	113	124	135	128	107	130	88	136	100	151	131	140	150	120
Actual calving interval	13.1	12.9	12.5	13.1	11.9	13.9	13.4	13.3	13.9	12.7	13.7	13.3	12.7	11.5	12.6	13.9	12.1	15.2**	14.5*	14.5*
Percent problem cows	13	10	12	7	10	24*	26*	27*	25*	17	6	11	5	18	11	15	7	20	20	8
Reproductive cull rate	25*	28*	36**	38**	25*	10	8.6	5	10	13	0	3	0	12	11	7	17	20	11	13

[a] = not calved, nor known pregnant within the last year * = significantly different, $p < 0.05$ ** = significantly different, $p < 0.01$

rate" and "percent problem cows". While the key indices measured the degree of reproductive success, "reproductive cull rate" and "percent problem cows" measured the degree of reproductive failure. Would it not be appropriate for veterinarians to equally emphasize the latter?

Fetrow (32) has made the point that culling reasons are subjective. Of all disposal reasons in our study, culling for infertility was the least subjective. Unsuccessful reproductive activity was well documented. Reasons for withdrawal from the breeding herd were often recorded by the attending veterinarian at the time of refusal of veterinary intervention, and these records were often used as a reference when collecting culling reasons at the time of disposal. Culling rates did require interpretation, as the time span between the decision to cull an animal and the removal of that animal from the herd varied within and across herds.

Since herd managers can maintain acceptable levels of reproductive efficiency by culling for infertility rather than production (33), failure to monitor the "reproductive cull rate" would inaccurately assess herd reproductive performance. The fact that five of the 14 problem herds had a significantly higher "reproductive cull rate" while their other reproductive indices did not differ, emphasizes the importance of this parameter. Our "reproductive cull rate" would have been more accurate had the denominator been average herd inventory or cow years of herd life rather than current herd size.

Practitioners failing to monitor "percent problem cows" and to identify problem individuals, may fail to understand a client's current concerns on herd visit day. Had we failed to monitor "percent problem cows", four of the 14 problem herds would not have been identified. The other reproductive parameters for those herds were not significantly different.

"Percent problem cows" was a measure of current reproductive failure and predicted future culling rate and/or future "days to conception". Problem cows had only two outcomes: If bred successfully they had a longer calving interval; if not bred successfully they were culled.

As an example, the index "percent problem cows" was high for herd G (Table 3). A higher future "reproductive cull rate" and/or longer future "days to conception" was predicted. Similarly, it was predicted that future "days to conception" and future "reproductive cull rate" would not improve in herds F,G,I. It may be important to monitor cows to be culled to better predict future cull rates and better interpret "percent problem cows".

At the beginning of the study, calving and breeding dates were collected. From these data, the current indices, "days to conception" and "percent problem cows", were available for immediate use. Both the historical indices "actual calving interval" and "reproductive cull rate", took more than a year to measure.

"Percent in heat by 60 days" was useful in showing that the two practices differed in prebreeding heat recording. When comparing herds between practices (Table 2), the Wisconsin practice was significantly better at collecting prebreeding heat data than the

Quebec practice, or Wisconsin herd owners were significantly better at reporting prebreeding heats than their Quebec counterparts.

Williamson (23) has observed the failure of herd managers to report prebreeding heats. This is substantiated by our data, as prebreeding heats were poorly reported in many herds. Managers for 12 of the 20 herds in Table 3 (herds C,D,E,G,H,J,L,M,N, O,R,T) were poor at reporting prebreeding heats. This was demonstrated by the fact that the difference between "days to first breeding" and "days to first heat" was fewer than 11 days.

When prebreeding heats were not reported and conception rate was high and prostaglandin was used, then heat detection rate was greater than 100 percent. This occurred in herds M and N (Table 3), where reported heats were greater than biologically expected heats.

The similarity in reproductive performance between cows (Table 1) and herds (Table 2) in Wisconsin and Quebec compares favorably with the observations of Tong *et al* (34). They reported that fertility levels in Quebec dairy herds are very similar to those found in commercial herds in California and New York State.

Excluding data on removed cows from the indices simplified interpretation. There is disagreement in the veterinary literature on whether to include (15,23,29) or exclude (4) data on culled cows. Interpretation of herd T parameters (Table 3) can demonstrate the effect of cull cow data. Because we excluded cows dead, sold for dairy purposes, or culled prior to the report date, we told the client that cows currently in his herd had historical reproductive inefficiency. This was possible because the historical measure of performance, "actual calving interval", was 14.5 months. We were also able to tell the client that his herd was currently performing more efficiently. This improvement was possible because the current measure of performance, "days to conception", was 120 days. Had we included removed cow data, we could not have said that the current herd had a history of poor performance. The significantly long "actual calving interval" could have been due to inefficient cows which had been culled. The improved performance could then have been related to culling rather than to biological change. Our interest was to report to a client the performance of his current herd. Indices were easier to interpret when based on an actual herd that a client could relate to, at a point in time.

The value for a herd index was well understood only when compared to the mean herd index and its SD. It was important that the mean was derived from a population of herds similar in size and socioeconomic characteristics to the herd being evaluated. This is different from the recommendations (3,7,14) that herd reproductive performance be evaluated by comparing a herd's reproductive indices against target values offered in the veterinary literature. The literature fails to provide a measure of variability that would permit statistical comparisons.

From the results of our study we suggest that some concepts promoted in the veterinary literature may not be useful for veterinary practice. Interference levels or action levels have been recommended by some authors (3,18). When our herd values were compared to the interference levels recommended by Radostits and Blood (3), every herd in our study had at least one herd index which was at an interference level. Had we followed those recommendations we would have had to investigate all the herds in our study.

This last observation is in agreement with Fetrow *et al* (35), who suggest that goals offered in the veterinary literature should not be accepted blindly because the difference between goals and interference levels may not be of practical importance. As reported by Weaver and Braun (7,36), our experience supports the principle that practitioners should first consider the client's objectives. It was more practical to regularly report and interpret herd parameters for a client than to formally set targets and interference levels. Our approach involved a continuing series of evaluations and interpretations. This differed from a diagnostic approach (3,13,14), which is in reaction to a client request. In our study, monitoring was proactive and designed to provoke improved performance.

Is there a significant difference between 115 and 134 "days to conception" for a 34 cow herd? What would be the norm for small dairy herds? Table 2 presents field data that offer mean indices as realistic norms. The SD for the means in Table 2 can help us appreciate how indices can vary without being significantly different. Using values in Table 2, a simple statistical model can be designed to identify herds with abnormal reproductive performances. An index could qualify as being high or low, long or short, if the value was greater than 1 SD but no greater than 2 SD from the mean. Thus, values within 1 SD would be within a normal range. Values 2 SD or greater from the mean could be considered abnormal. Some clients were congratulated for significantly better performances while others were made aware of significant losses.

Evaluating parameters independently may not be sufficiently sensitive in detecting problem herds. For example, herd R (Table 3) had both a "high" reproductive cull rate and "high" "percent problem cows". The sum of these measures of current and historical failure was greater in herd R than the same sums in herds A,B,E,F,G,H,I. These latter herds were identified as having reproductive failure. Herd R was not identified as having reproductive failure because there was a greater balance between current and past failure.

It may be desirable to develop a more complex statistical model to more accurately weigh a panel of parameters. In agreement with Williamson (23,24), our herd reproductive parameters were generally observed to have a distribution skewed to the right. In these situations, Martin *et al* (31) have proposed a more appropriate method of measuring variability.

Table 4 compares our mean indices with those reported by Tong *et al* (34) and Williamson (23,24). As they did not report standard deviations, we were unable to make statistical comparisons , and our data may differ from theirs. Ours was collected as we worked within a practitioner/client relationship, whereas theirs was collected within a university-funded research program. Differences would occur because herds were not selected in the same manner. Though

Table 4. Comparison of mean herd reproductive parameters to previously reported herd and lactational means

	Mainframe			Microcomputer		
	DHAS[a] (2216 lact)	HHP[b] (21 herds)		VRKS[c] (87 herds)		
	$\overline{X}$	$\overline{X}$	Range	$\overline{X}$	SD	Range
Herd size		56	27–191	42	15	21–112
1st service conceptions	47	46	17–67	51	14	21–91
Services per conception	2.0	2.0	1.4–3.0	1.9	0.4	1.1–3.0
Days to 1st breeding	88	80	68–113	81	13	60–135
% in heat by 60 days		48	11–88	35	17	9–76
Heat detection rate		65	47–85	57	25	33–231
Days to conception	121	107	91–137	118	17	78–151

[a]Tong *et al* (33) used DHAS and CIAQ records
[b]Williamson (23,24) used a herd health program
[c]Present study used a veterinary recordkeeping software

they did not present definitions for their indices, it is improbable that indices were calculated in exactly the same manner.

Errors in our data would be errors of omission. One of two breedings on one heat and breedings not resulting in conception could have been omitted. This was more probable in herds with bulls or herds with an owner inseminator. This bias is most likely shared with many DHIA data centers or other organizations collecting breeding data on commercial farms. One bias that DHIA data would have, but we did not have, is the assumption of pregnancy. Our mean "actual calving interval" of 394 days (SD 20.3) compares with 395 for 7769 Quebec herds averaging 38 cows for 1989 (37).

Evaluation and comparison of reproductive indices is complicated by the fact that there are many methods currently being used (4,15,29). The definition of an index may need to vary depending on the resources available to perform complex calculations, the objectives of the user, or when the data are imperfect. Our observations suggest that users should fully understand the indices that are chosen. Indices should then be compared across herds, practices, and regions to establish statistically meaningful baseline values.

Martin *et al* (31) have proposed a heirarchically structured data collection system. Implementation of such systems has been attempted at universities (23,24,30,38,39). Our study suggests that such systems can be implemented by veterinary practices.

Dohoo (39) has reported that uses for microcomputers are limited because their "programs lack the ability to make comparisons between farms or to easily amalgamate data from various sources or geographic regions". Our study shows that microcomputer programs can pool and compare herds, practices, and regions. This study suggests that microcomputer programs not only have the ability to monitor client herds but can also help practitioners measure their own performance.

Stowe (40) reported that "the problem with computer software available to the farm service sector of veterinary practice is that there is no clear delineation of practical usage". In our study we have shown that veterinary record-keeping software (12,20,21,25–27) can pool herds and provide herd, practice, and regional means. This differentiates it in practical usage from programs that monitor single herds either on a farm or in a veterinary practice (2,22,41–43).

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