The multifactorial approach to fertility

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Feeding for efficient milk production is key in modern dairy practice. Efforts to maintain production and fertility at optimal levels under given market, husbandry and feeding conditions often fail. Yet, financial losses for an 'open day' are estimated in various studies to be US$2.5-5.0.

Production or fertility?

A common complaint in recent years is that it is not possible to maintain both production and fertility at optimal levels. Fig. 1, taken from the State of New York is a typical example.

Data from Israel shows that things could be different. Fig. 2 shows that higher production has been accompanied by a better pregnancy rate.

This article describes the Israeli (multifactorial) approach to fertility and health problems, which, in the author's view, made such an achievement possible.

Multifactorial approach

Like most production traits and infectious diseases, fertility problems are multifactorial. Fig. 3 evaluates the risk factors responsible for poor fertility in 144 Israeli herds during 1996.

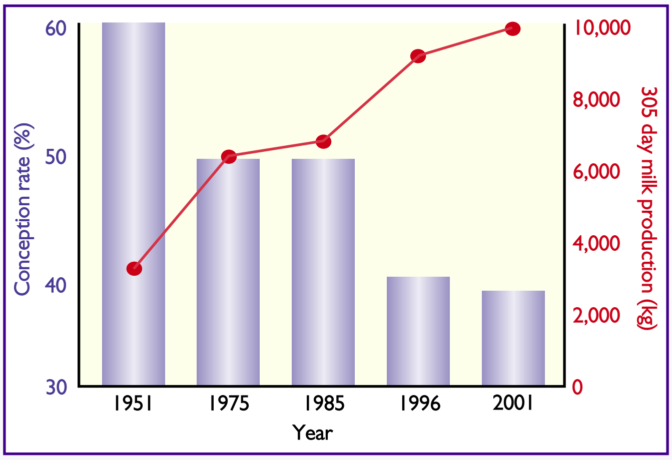


Fig. 1. The inverse relationship between conception rate (%) and milk production (New York).

If fertility is a multifactorial entity and involves various disciplines, then a multifactorial approach is called for.

This approach is in contrast to others advocated elsewhere. In fact, the choice is between the double blind PG and the multifactorial approach to fertility problems.

Details of the multifactorial approach and the routine veterinary work in dairy herds advocated by the author, and practised in Israel since the early 1990s, are found elsewhere, but some major points will be described in this article.

The data are, unless otherwise stated, from 3,620 lactations of primiparous cows and 5,757 lactations of multiparous cows, all calving between January 1995 and June 1998 in seven herds.

All the results presented are the outcome of logistic or linear regression models. If not stated otherwise, effects of herds, years, parity and season are allowed for in all models.

Only results with a statistical significance of $p<0.05$ are shown. As in other areas of herd health, fertility is monitored periodically and data is exported from the farm's computer.

The monitoring report alerts against any fall from preset targets, and is short, concise, and regularly issued.

Targets are used as a challenge for farmers. An example of a monitoring fertility report for a sample herd is shown in Table 1.

Causal analysis

Factors contributing to lower fertility indices (not pregnant to first service, open ≥150 days from calving, open days, and to unobserved heat respectively) are routinely evaluated for the various herds by different logistic and linear regression models. The results are presented in the herd health reports in subsections of lactation number.

The statistically significant results, together with the respective number of cows 'with factor' out of 18 factors evaluated, for second lactation cows in the sample herd, are presented in Table 2.

Herd size is a limiting factor for

Fig. 2. Milk production (kg/305 days) and conception rate in Israeli herds (cows).

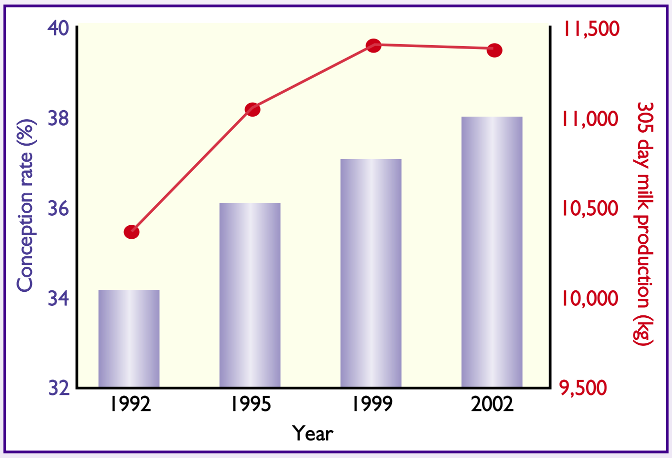
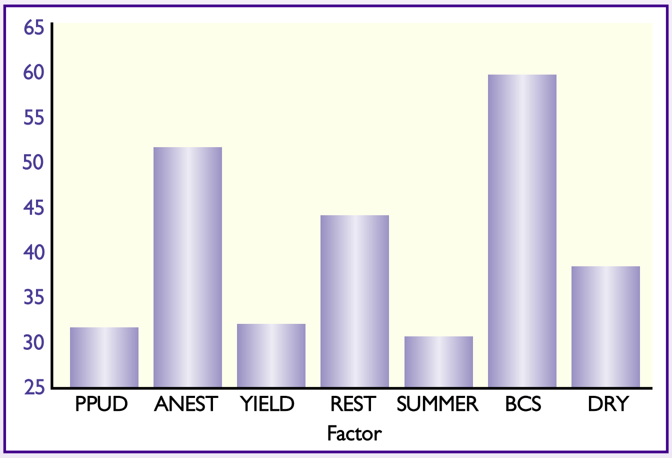


Fig. 3. Factors responsible for lower fertility (% of 144 Israeli herds in 1996). PPUD = calving diseases; ANEST = unobserved heat; YIELD = high yield (FCM) before service; REST = rest period, either too short or too long; SUMMER = summer calvings; BCS = either too fat or too thin at calving; DRY = with dry periods either too short or too long.



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both statistical and epidemiological reports. Herd health reports when issued for small sized herds or cover short periods often prove futile.

The models can be successfully applied to small herds of 50 cows by limiting the number of variables confounded in any one model.

Calving diseases

Most calving diseases have adverse effects on future fertility. While crude risks or estimates look at both direct and indirect effects, summary risks only consider the direct ones (after effects of other calving diseases are allowed for).

Both summary and crude risks could be of value when measures for control on the farm are considered. The relative contributions of calving diseases to impaired fertility in terms of summary risks are presented in Table 3.

Pre-service unobserved heat

Pre-service unobserved heat has an adverse effect on fertility in most herds. Unobserved heat can result from poor management, nutrition, various calving diseases, feet problems and other factors. Risk of recurrence for inactive ovaries was found to be 1.8.

The various effects on unobserved heat and on ovarian inactivity were evaluated (Table 4). Respective rates of unobserved heat and ovarian inactivity were 36.2 and 10.1% for primiparous cows and 42.5 and 10.3% for multiparous cows. Based on our studies the epidemiology of inactive ovaries is shown in Fig. 4.

Negative energy balance

Negative energy balance (NEB) after calving due to rising production and the increasing risk for a negative selection associated with it is, at present, a major risk for the industry.

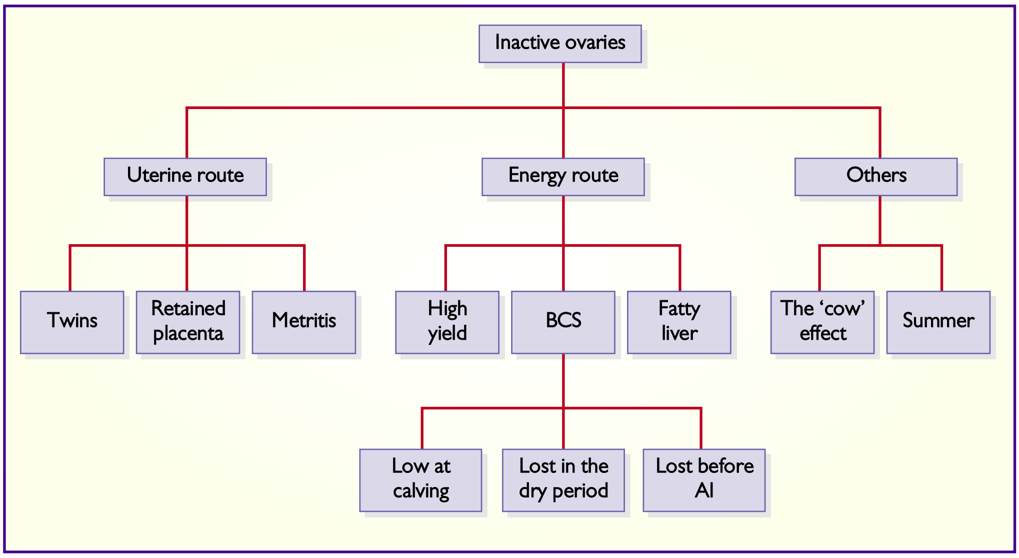

Fig. 4. The epidemiology of inactive ovaries.

The effects of a NEB on fertility can be either direct on the pregnancy rate, or indirect through its effect on anoestrus.

A change in the body score, which reflects fat mobilisation to get energy balance, is the gold standard used to evaluate NEB in the field.

In the data set mean losses of BCS (see Fig. 3) from calving to 40-60 days in milk were 0.57±0.44 u BCS for first, and 0.64±0.49 u BCS for older lactations respectively.

Cows of higher parities, those with longer dry periods, heavier at calving, after calving diseases and with higher peaks lost more BCS before AI.

The associations of fertility indices with some measures used in the field for evaluation of NEB were compared (Table 5). The respective rates of unobserved heat, failure to conceive to first AI service, and being open >150 DIM were 37.3, 61.6, and 26.5%.

The associations between losses of BCS from calving to AI, and the ratio between the fat to protein ratios in the test days following and preceding the first AI respectively proved to be the strongest and most similar.

Cycles' distribution

Pregnancy rates are affected by the length of the cycle and those after regular (medium) cycles are higher.

The cycles in the analysis are the inter-inseminations interval, their classification and the respective goals (the means of the best quarters of the Israeli herds). The high rates of medium (regular) cycles are the manifestation of the common use of pedometers in those herds.

By studying the effects of various factors on the first two cycles, valid statistical associations were established, which are somewhat in contrast to traditional explanations of long and double cycles, with long dry periods, calving diseases, negative energy balance after calving, unobserved heat, parity, season, and location of cows.

As the sensitivity and accuracy of heat detection by pedometers, and by all other methods, are largely affected by the level of the threshold, it is possible to apply different thresholds to various groups of cows.

Table 1. Example of a reproduction monitoring report.

Reproduction Total calved	Heifers 222		Primipara 177		Multipara 356	
Not inseminated by 150 DIM (%)			5.1	(10.0)	17.1	
Loss of BCS from calving to 1st service (n)			161		292	
– Lost ≥0.5 u (%)			**45.3**	(40.0)	**54.8**	(40.0)
Unobserved heat (%)	**17.1**	(10.5)	20.8	(26.6)	27.8	(31.3)
Inactive ovaries (%)	**2.3**	(0.5)	**10.1**	(5.9)	**11.5**	(6.9)
Mean rest period (days)	14.8		112.0		105.0	
Pregnant to first service (%)	**68.9**	(69.5)	**37.5**	(47.4)	**32.9**	(38.2)
Open >150 DIM (%)	**5.4**	(1.0)	**45.8**	(31.6)	**46.2**	(36.7)
Mean open days (150 days limit)[a]			**132**	(117)	**129**	(116)
Cycles distribution (% in days)						
– Total	92		290		430	
– Short cycles, 5-17 days	**10**	(3)	**4**	(3)	5	(5)
– Medium cycles, 18-24 days	**54**	(77)	**64**	(72)	**59**	(66)
– Long cycles, 25-36 days	**9**	(6)	**10**	(9)	**13**	(12)
– Double cycles, 36-60 days	**27**	(14)	**22**	(16)	**24**	(17)

Values in brackets are targets **Values in bold denotes short of targets** [a]18 months for heifers

The voluntary rest period

Mostly, but not always, first service pregnancy rate improves with time from calving. This effect is in contrast to that on the open period.

The odds ratio of not being pregnant to first service was 0.9 (p<0.01) and an estimate of an additional 5.1 days open (p<0.01) were associated with each additional 10 days of rest.

The models also allowed for the effects of calving diseases and unobserved heat. Estimates for additional days of rest associated with various risk factors are presented in Table 6.

Recommendations for the optimal rest period for cows on specific farms are debatable. Few economical models have been suggested, taking into account milk yields and persistencies, feed costs, and prices of replacements and calves.

Body condition score

It was found that cows calving in a higher body condition had a better fertility. Odds ratios were also adjusted to the effects of peak yield and postparturient diseases.

No association could be established between pregnancy rate to first service and body condition score at calving (BCSC), but odds ratio suffering from unobserved and inactive ovaries were 0.5 and 0.2 respectively, and open period was shorter (6.3 days) for each additional 1.0 unit BCSC in primiparous

		SECOND LACTATION							
		Number 121		Pregnant (%) 33.1		Open>150 DIM (%) 46.7		Open days 129	
Factor	Value	With	Without	With	Without	With	Without	With	Without
Unobserved heat		32	89			*62.5	40.9	**141	122
Short rest periods[2]	92	39	82			*28.6	57.7	**112	136
Summer calvings		50	71	**20.0	42.3	**62.0	35.7	*133	122
Low BCS at calving[1]	2.50	44	76	†22.7	39.5				
Lost ≥0.5 u BCS in the dry period		28	88	*17.9	38.6			*139	123
Negative energy balance at calving	1.293	24	70	†25.0	40.0				

†p<0.1; *p<0.05; **p<0.01 [12]Lowest (shortest) or highest (longest) thirds

Table 2. Factors responsible for lower fertility in second lactation cows.

cows. The only association established in multiparous cows was with inactive ovaries (odds ratio of 0.4).

The effects of body condition at calving on fertility traits in this data were mainly in the first three months after calving and they diminished with time.

The results suggest that a low BCSC is a determinant of reduced fertility mainly by delaying the onset of ovarian activity.

The dry period and BCS

Data from 4,578 lactations of multiparous cows in 57 herds (calving in 1996) was used to evaluate the effects of changes in BCS during the dry period on fertility.

Effects of herds, parity, season, BCS at drying off, birth of twins and length of dry period were included in all models.

Mean of BCS at drying off was 3.29±0.5 units SD. Respective rates of cows losing ≥0.5 units or gaining ≥0.25 units in the dry period were 25.9 and 24.3%.

Odds ratios of cows suffering from unobserved heat were 0.8 and 1.2 for cows gaining or losing BCS in the dry period respectively compared to those with no such changes.

No associations could be established between failure to conceive to first AI service and BCS changes, while the risk of being open >150 DIM was 1.3 as higher for cows losing BCS compared to those with no changes.

In contrast to the strong association that was established previously between production and the length of the dry period, we failed to achieve it with the fertility variables.

The only valid statistical association that was established was that between unobserved heat and the length of the dry period, odds ratio of cows suffering from unobserved heat was 1.1 more for each 10 days of dry period.

Summer calvings

The negative effect on fertility of the summer under Israeli conditions could be high. Although this factor reflects any effects associated with the summer, it was assumed that climatic effects (heat stress) are the main ones.

From data of 109 herds in 1993, it was found that transferring 1% of the cows in the Israeli National Herd from winter to summer calving was associated with an additional 17 days open for each cow in the country.

The results obtained on each individual farm should be interpreted in the light of the following considerations:

● Quotas. Many farms with extra production potential direct cows to calve in the summer due to the season differential pricing of milk. Therefore, any additional income should be weighed against loss of milk.

● Financial returns from investment in better housing, shading and cooling systems.

High somatic cell counts

It had been suggested that the phenotypic unfavourable correlated changes in lactation mean somatic cell count and conception rate at first service are associated with the genetic improvement of mature equivalent milk yield.

The effects of high somatic cell counts (HSCC) on some fertility traits were analysed. A first lactation cow with an SCC of >200,000 and second or more lactations cows with an SCC of >400,000 milk tests in at least two out of the six first milk tests were defined as having HSCC.

The rate of HSCC was 34.3%. Odds ratios of cows not being pregnant to first AI and to be open >150 DIM were 1.13 and 1.20 respectively, compared to those with low SCC. The strong association that was established between HSCC and calving diseases called for confounding them in all models

Common factors

Common factors are the sum of the residuals and represent unknown factors not included in the models. Special designated investigations must be carried out to reveal them.

Factors claimed to lower fertility include:

● Nutritional factors such as increased protein intake, excess of rumen degradable protein, unbalanced minerals and micro-elements feeding and others.

● Infectious diseases such as leptospirosis, IBR, BVD.

● Toxic factors such as oestrogen, nitrates, and gossypol.

Automation observations

More automation will lead to better data, both in quantity and in quality. Many milking systems have already automated components that replaced, partly or completely, the need for manual observations (milk recording, milk conductivity, and pedometers).

Body condition scoring (BCS) of

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Trait	Rate (%)	Unobserved heat	Inactive ovaries
Primiparous cows (n=1530)			
Summer calvings	30.7		0.4**
BCS at calving, units	3.41±0.33	1.3*	0.5**
Postparturient diseases	56.3	0.7*	1.6**
Multiparous cows (n=2231)			
Summer calvings	28.4	1.2*	
BCS at drying off	3.33±0.48		0.1**
BCS*BCS at drying off			1.5**
Lost ≥0.5 units BCS in the dry period	27.7	1.3*	
Gained ≥0.25 units BCS in the dry period	21.5		
Daydry<60 days	15.4		
Daydry >75 days	9.8	1.4*	
Postparturient diseases	35.1	1.8**	1.8**

*p<0.05 **p<0.01

Table 4. Factors responsible for unobserved heat and inactive ovaries in 3761 lactations (six herds calving between Jan 1995 and May 1998.

Table 3. The association of fertility traits with calving diseases and traits (3,620 and 5,757 lactations of first and second or more lactations respectively in seven herds for cows calving between Jan 1995 and June 1998).

	Rate (%)		Unobserved heat[a]		Inactive ovaries[a]		Not pregnant to first AI[a]		Open >150 days[a]		Rest Period[b]	
Lactation	1st	≥2nd	1st	≥2nd	1st	≥2nd	1st	≥2nd	1st	2nd	1st	≥2nd
Twin		6.0		1.6**		2.3**		1.3*		1.4*		5.0**
Still	6.7	3.9	1.3*				1.4*		1.4*			
MF		1.9		0.6**				0.7*				-5.4**
PRO	0.4	0.3		5.3**		4.6**	4.6*		3.0*	2.8*		
DA	0.4	0.9										
RP	17.7	17.0	1.4**	1.5**	1.8**	1.8**		1.5**	1.5**	1.7**	2.1†	3.5**
MET	31.3	13.9		1.3**	1.5**	1.6**		1.3**	1.3**	1.4**	2.0*	2.7**
KET	0.9	6.3		1.3†				1.4*				3.8**
EDEMA	6.9						0.8†					

†p<0.1 *p<0.05 **p<0.01; TWIN = multiple births; STIL L= stillbirth; MF = milk fever; PRO = prolapsed uterus; DA = displaced abomasum; RP = retained placenta; MET = primary metritis; KET = ketosis; [a]Odds ratio suffering from the trait for a cow 'with factor', [b]Estimates of additional days of Rest Period for a cow 'with factor'. [c]Effects of herds, years and summer were included; [d]Effects of herds, years, parity and summer were included

Variable[a]		Unobserved heat	Not pregnant to 1st AI	Open >150 DIM
	Rate/value	37.3	61.4	26.5
Additional 1.0 u BCS at calving		0.8**		
Lost ≥0.75 u BCS from calving to 50 DIM	42.9%	1.3**	1.1†	1.2**
Fat/protein ratio first test day>1.4[a]	16.4%	1.3**		
Fat/protein ratio next/preceding AI[b]	1.080	1.4**	1.2*	1.3**

†p<0.1 *p<0.05**p<0.01 ***p<0.001; Stepwise logistic regression models also included the effects of herd, year, parity, summer and calving diseases; [a]Effects of DIM was included ; [b]Highest quarter

Table 5. Fertility traits and various measures of negative energy balance (4510 lactations in six herds).

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dairy cows in various stages of the lactation is the most important tool used to evaluate the energy balance of cows over the lactation in the field.

The two major handicaps of BCS are its low objectivity and resolution (0.25 units in a scale of 1 to 5).

SAE Afikim's Afiscale is an automated scale, which is an integral part of their Afimilk system. Body weight (BW) data derived from the Afiscale was used in the models.

The results show that BW can replace BCS in the models evaluating the effects of NEB, not only when differences between BW in the various stages of lactation are calculated, but also when used as a single measurement.

Table 6. Estimates of additional days in the rest period (3761 lactations of cows calving in six herds in the period between Jan 1995 and May 1998) associated with various factors.

Factor	Primiparous cows (n=1530)[a]		Multiparous cows (n=2231)[b]	
	Rate/Mean	Estimate	Rate/Mean	Estimate
Summer calvings[c]	30.7		28.4	-1.5*
BCS at calving, units	3.41±0.33		3.15±0.46	
Postparturient diseases	56.3		35.1	
BCS lost between calving and AI	0.58±0.44	1.8†	0.64±0.49	
Unobserved heat (active ovaries)	26.1	9.1**	32.3	6.9**
Unobserved heat (inactive ovaries)	10.1	33.0**	10.3	29.9**

[a]Effects of herd and year were included; [b]Effects of herd, year and parity were included. [c]April through to August.
†p<0.1, *p<0.05. **p<0.01

On-line analysis of milk fat and protein is now possible and will allow for better diagnosis, retrospective analysis and decision making.

Conclusions

Today, routine health reports based on epidemiological models are a common tool used by farmers, veterinarians and nutritionists in Israel and in some other countries.

Though experts prepare the reports, their improving quality is the result of routine practice evolved through understanding of the multifactorial nature of modern veterinary issues.

Through their postgraduate training, most practicing veterinarians are capable of reading the reports, interpreting them and implementing the conclusions in their practice.

The author believes that future improvement of fertility in practice will be possible in three main fields:

- Improvement of data through automation.
- Development of multidisciplinary models including economical evaluations.
- Improvement of methods applied to small herds. ■

References are available from the author on request.