THE MULTIFACTORIAL APPROACH TO FERTILITY PROBLEMS

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Feeding for efficient milk production leads 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 2.5 to 5.0 US$. Losses of income that could be attributed to health problems and managemental mistakes affecting fertility and identified in a routine Herd Health Report issued to an Israeli herd of 500 cows for the year 2005 were estimated at US$ 59,129 (Table 1). Given value for one open day was 3.00 US$.

Table 1. Economical evaluation of losses of income that could be attributed to health problems and managemental mistakes for the year 2005 in an Israeli herd

What did we loose money for (US$)?			(--X-)
9820603	**milk**	**fertility**	**total[1]**
Summer calvings	0	10,681	6,418
long or short dry periods	0	853	853
Lost BCS in the dry period	0	0	0
Over- or under-conditioned at calving	10,007	2,291	12,298
Calving diseases	11,599	4,953	4,702
NEB at calving	4,702	0	4,702
NEB at AI	0	0	0
Unobserved heat	0	6,482	6,482
Long rest period	0	0	0
Replacements & structure of herd	3,934	6,733	15,610
Mastitis	19,069	0	28,524
Abortions	0	1,887	34,890
Total	**49,311**	**59,129**	**157,972**

[1]includes other expenses   **10.0% - of the estimated income from milk**

Should increasing production ultimately lead to lower fertility?

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

Data from Israel (2) shows that things could be different (Figure 2); higher production had been accompanied by better pregnancy rate. The present presentation describes the **Israeli (multifactorial) approach** to fertility and health problems, which, in the author's view, made such an achievement possible.

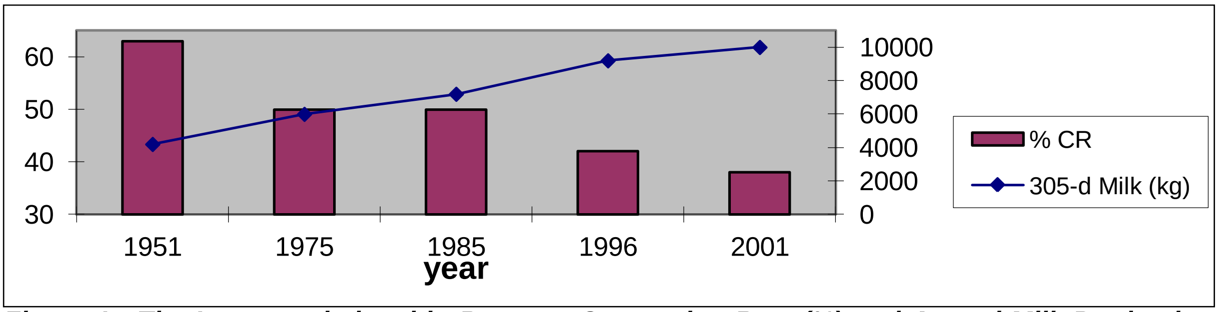


Figure 1. The Inverse relationship Between Conception Rate (%) and Annual Milk Production (New York)

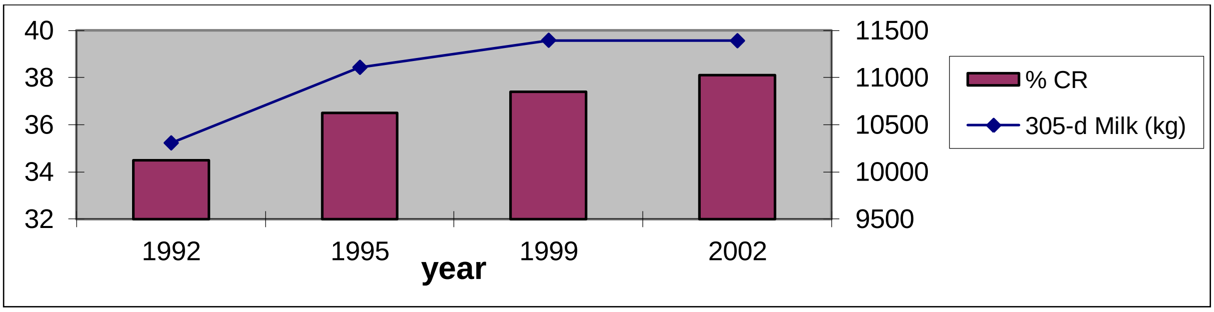
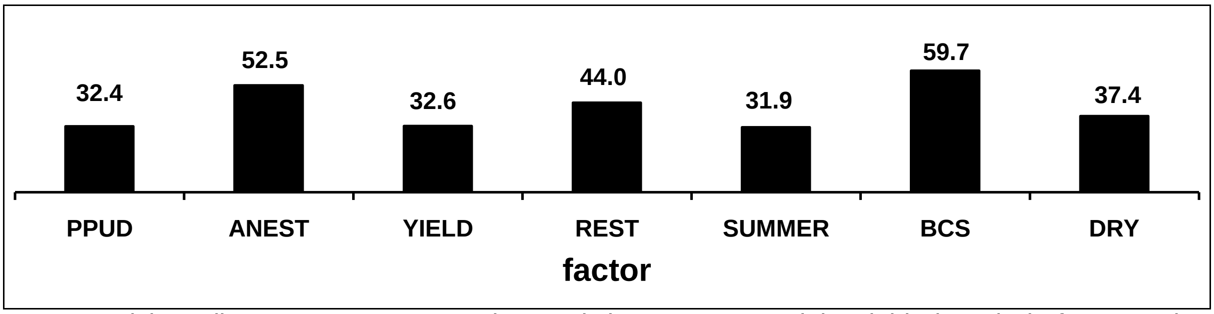


Figure 2. Milk production (kg/305 days) & Conception Rate in Israeli herds (cows)

The "Double Blind" (PG) versus the "Multifactorial Approach" to fertility problems

Like most production and infectious diseases and traits fertility problems are multifactorial as illustrated in Figure 3 that evaluates risk factors responsible for poor fertility in 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

Figure 3. Factors Responsible For Lower Fertility (% Of 144 Israeli Herds In 1996)

If fertility is a multifactorial entity and involves various disciplines, a **"multifactorial approach"** is called for. This approach is in contrast to others advocated elsewhere, for example by Ferguson and Galligan (3); **in fact, the choice is between "The Double Blind (PG) versus the Multifactorial Approach to fertility problems"**. Details of the multifactorial approach and the **routine veterinary work in dairy herds** advocated by the author, and practiced in Israel since the early 1990th are found elsewhere (4), some major points will be described in the present paper. The data are a) from 3620 lactations of primiparous cows and 5757 lactations of multiparous cows, all calving in the period 01/95-

06/98 in 7 herds from the author's own practice (Nir-Galon set); and b) from a recent survey of 5,364 lactations in 30 Israeli herds calving in the period 03/2003-09/2004 (Herd-Book set)

Monitoring fertility

As in other areas of herd health, we monitor fertility periodically; data are exported from the farm's computer. An example of a part monitoring fertility of our Sample Herd is in Table 2.

Table 2. Reproduction Report, Sample Herd #9820603. Calving period 01/10/04-30/09/05

Reproduction	Heifers		Primipara		Multipara	
a. Total calved	**186**		**135**		**363**	
b. % Not inseminated by 150 DIM			7.4	(10.0)	7.4	
c. Loss of BW from calving to 1st service (n)			117		322	
% Lost ≥0.5 u BCS			46.2	(40.0)	60.6	(40.0)
d. % Unobserved heat	45.7	(10.8)	45.9	(23.2)	39.7	(25.8)
e. % Inactive ovaries	2.7	(0.9)	10.5	(5.0)	11.4	(4.8)
f. Mean rest period (days)	14.5		100.0		73.0	
g. % Pregnant to first service	56.2	(69.5)	38.4	(47.3)	22.0	(38.7)
h. % Open >150 DIM	4.9	(0.9)	45.5	(36.9)	52.0	(44.1)
i. Mean open days (150 days limit)[a]			129	(122)	124	(123)
j. Cycles distribution (% in days)						
1) Total	146		229		804	
2) Short cycles, 5-17 d	8	(4)	8	(4)	9	(6)
3) Medium cycles, 18-24 d	56	(75)	57	(69)	55	(65)
4) Long cycles, 25-36 d	5	(4)	12	(9)	12	(12)
5) Double cycles, 36-60 d	31	(17)	23	(18)	25	(17)

Values in brackets are targets *denotes values short of targets.* [a] *18 month for heifers*

Causal analysis of infertility

The models

Various factors contributing to lower fertility are evaluated by four different models. The results are presented in subsections according to lactation number. a) **Contribution to "Not pregnant from first service"**. In the model (based on logistic regression), the contributions of the various factors are quantified to percentage of "total non pregnancy" from first service; b) **Open greater than 150 days from calving, %**. Rates of cows open greater than 150 days from calving with various factors are compared using Mantel Haenszel technique to those without ones. Other factors, as called for, are controlled; c) **Contribution to "open days"**. A linear regression model in which the various estimates are the additional open days attributed to the respective factors. Upper value for the open days is 151 days; d) **Contribution to anestrus**. In the model (based on logistic regression), the contributions of the various factors are quantified to percentage of total anestrus.

The statistically significant results together with the respective number of cows are presented in separate tables for each lactation group, the statistically significant ones for second lactation cows in our Sample Herd, 9820603 is presented in Table 3.

Herd size is a limiting factor for both statistical and epidemiological reports. Herd health reports when issued for small sized herds or cover short periods often prove futile. We are able to apply the models successfully to small herds of 50 cows by limiting the number of variables evaluated in any one model.

Table 3. Factors responsible for lower fertility in second lactation cows, herd #9820603

Second lactation								
	n		% pregnant		% open[3]		open days[4]	
	185		24.3		50.3		122	
factor	with	without	with	without	with	withou	with	without
Calving diseses	74	111			59.2†	44.2		
Unobserved heat	88	97	18.2*	29.9	59.1**	42.6	130**	113
Summer calvings	56	129	3.6**	33.3	66.1**	43.6	139**	112
Lost ≥0.5 u BCS before service	110	71			54.5**	39.4		

*†p<0.1; *p<0.05; **p<0.01*

[12] Lowest (shortest) or highest (longest) thirds

[3] Open more than 150 DIM

[4] Upper limit 151 days

The risk factors (independent variables)

Calving diseases

The relative contributions of calving diseases to impaired fertility are presented in Table 4.

Table 4. The association of fertility traits with calving diseases and traits (9377 lactations in 7 herds for cows calving 01/95 through 06/98).

Trait	Rate (%)	Unobserved heat[a]		Inactive ovaries[a]		Not pregnant to first AI[a]		Open >150 days[a]		Rest Period[b]	
Odds ratio		"r"	"R"	"r"	"R"	"r"	"R"	"r"	"R"	"r"	"R"
Primiparous cows (n=3620)[c]											
Induction	9.4			0.7†	0.6*			1.4*			
Stillbirth	6.7	1.3†	1.3*			1.4*	1.4*	1.5**	1.4*		
Prolapse	0.4					5.2*	4.6*	3.7*	3.0*		
LDA	0.4										
RP	17.7	1.5**	1.4**	1.4*	1.8**			1.4**	1.5**		2.1†
metritis	31.3			1.3†	1.5**			1.2†	1.3**	1.5†	2.0*
Ketosis	0.9										
Mastitis	0.7										
edema	6.9					0.8*	0.8†				
Multiparous cows (n=5757)[d]											
Induction	2.3								1.4†		
Twins	6.0	1.9**	1.6**	2.9**	2.3**	1.6**	1.3*	1.8**	1.4*	6.4**	5.0**
Stillbirth	3.9	1.6*						1.7**			
Milk fever	1.9	0.6*	0.6**				0.7*			-4.4*	-5.4**
Prolapse	0.3		5.3**		4.6**			3.2*	2.8*		
LDA	0.9			2.2*						4.6†	
RP	17.0	1.6**	1.5**	1.9**	1.8**	1.5**	1.5**	1.7**	1.7**	4.1**	3.5**
metritis	13.9	1.3**	1.3**	1.5**	1.6**	1.3**	1.3**	1.4**	1.4**	2.4**	2.7**
Ketosis	6.3	1.4**	1.3†	1.4†		1.5**	1.4*	1.4**		4.9**	3.8**

*†p<0.1 *p<0.05 **p<0.01 [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*

Most calving diseases have adverse effects on future fertility. While crude risks or estimates sum both direct and indirect effects, summary risks sum only 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.

Pre service unobserved heat

Pre service unobserved heat has an adverse effect on fertility in most herds. Unobserved heat can result from poor management, nutritional factors, various calving diseases, feet problems, and the "cow factor". Risk of recurrence for inactive ovaries was found by us to be 1.8 (5). Based on our studies we summed the epidemiology of inactive ovaries in Figure 4.

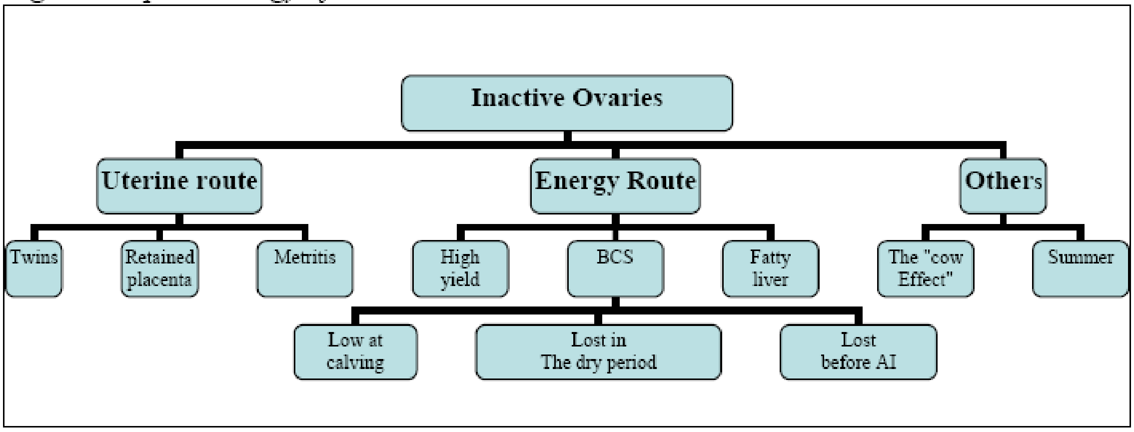


Figure 4. The epidemiology of inactive ovaries.

Having data on **BCS,** we reevaluated the various effects on unobserved heat and on ovarian inactivity (Table 5). 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. Effects of herd, years, and parity (for multiparous cows) were allowed for in all models.

Table 5. Factors responsible for unobserved heat and inactive ovaries in 3761 lactations (6 herds calving period 01/95-05/98)

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<0.05p<0.01*

Estrous synchronization in the dairy herd might fail due to negative energy balance **(NEB)** of many cows before breeding. Our own experience offers an explanation why pregnancy rates after injection of prostaglandin are at times lower than expected. In the study carried out in one herd, results of milk progesterone were available at the time of the rectal palpation of cows with unobserved heat. We divided the cows into three groups: a) with milk progesterone level of ≤5.0 ng/ml; b) with milk progesterone level of >5.0 to ≤10.0 ng/ml; and c) with milk progesterone level of >10.0 ng/ml. Only cows with progesterone level of ≥5.0 ng/ml were injected with **PG** and were presented to the **AI** inseminator, who inseminated only the ones that were on heat. The results (Table 6) show, that although rates of cows inseminated with the two levels of progesterone were similar, pregnancy rate of the cows with the high level of progesterone at the day of treatment with **PG** was higher.

Table 6. Milk progesterone (ng/ml), prostaglandin treatment, and pregnancy rate

	n cows	**Milk progesterone (ng/ml)**	
		5.0-10.0	**>10.0**
% inseminated	211	89.6	86.1
% pregnant	185	24.1	40.5

Negative energy balance (NEB)

The effects of a **NEB** on fertility can be either direct on the pregnancy rate, or indirect through its effect on anestrus. The associations of various factors with the rate of loss of **BCS** from calving to 40 - 60 days are presented in Table 7. Mean losses of **BCS** 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 period, heavier at calving, after calving diseases, and with higher peaks lost more **BCS** before **AI**.

Table 7. Estimates of effects on loss of units of **BCS** from calving to 40 - 60 days (3761 lactations of cows calving in 6 herds in the period 01/95-05/98) associated with various factors

Factor \ Estimates	**Primiparous cows (n=1530)[a]**	**Multiparous cows (n=2231)[b]**
Summer calvings[c]		
Postparturient diseases	0.09**	0.10**
BCS at calving, units	0.33**	0.32**
Peak yield, kg	0.01**	0.01**
Daydry, days		0.03**
Daydry*daydry, days^2		-0.00014**

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

A change in the body score, which reflects fat mobilization to get energy balance, is a preferable indicator. Conception was lower in cows that lost more than 1 unit **BCS** (out of 5) in body condition score from calving to service than in those that regained their score at calving (6). Our results are similar (Table 8) the adverse effects of **NEB** on fertility are better evaluated when fertility is associated with loss of ≥0.5 units **BCS** from calving to 60 days in milk.

Table 8. Fertility traits, **BCS** at calving, and the loss of **BCS** in the first 40 to 60 days of lactation. (3761 lactations in 6 herds)

	Fertility traits		
	additional 1.0 u BCS at calving	**loss of ≥0.75 u of BCS between calving & AI**	**1.0 kg 3.5% FCM/day produced in the first 90 DIM**
To suffer from unobserved heat	0.8**	1.3**	
To suffer from inactive ovaries	0.5**	1.9**	1.03*
Not to be pregnant to first AI		1.3*	
To be open >150 days		1.3*	

p<0.05p<0.01*

Milk fat to protein ratio and energy balance

Because milk fat concentration tends to increase and milk protein concentration tends to decrease during the postpartum negative balance, the fat to protein ratio was suggested as a potential indicator of a lack of energy supply through feed (7). Associations between parameters derived from regular milk control data were evaluated by Heuer et al (8). We used our data (the Nir-Galon set) to evaluate the association between selected fertility traits and various variables describing negative energy balance in practice (Table 9). The associations between losses of **BCS** from calving to **AI**, fat to protein ratio in the test preceding first service 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 (*9*).

Table 9. Fertility traits and various measures of negative energy balance (4519 lactations in 6 herds).

Variable[a]		**Unobserved heat**	**Not pregnant to 1st AI**	**Days Open**
	Mean\value	37.3	61.3	107.4
Lost ≥0.75 u BCS from calving to AI	43.0	1.25**	1.13†	3.6**
Fat/protein ratio first test day[b]	1.330	1.22**		
Fat/protein ratios 2nd/1st test days[b]	1.047	0.85*		
Fat/protein test preceding AI[b]	1.230	0.75**		-4.3**
Fat/protein ratio next/preceding AI[b]	1.080	1.26**	1.18*	3.1**
FPCM 90 days[b]	3722		0.79**	

*†p<0.1 *p<0.05 **p<0.01 ***p<0.001; [a]Herd, year, and parity were used as dummy variables. Effects of summer and calving diseases were included; [b]Highest quarter*

Cycles' distribution (%)

The "cycles" in our analysis are the inter inseminations interval and are classified to short (5 to 17 days), medium (18 to 24 days), long (25-35 days), and double (36 to 60 days). The targets (Table 2) are 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. Pregnancy rates are affected by the length of the cycle (10) those after regular (medium) cycles are higher.

Cycles of various lengths are traditionally explained as follows: a) short cycles represent estrogenic activity in the ration, services after hormonal therapy, or a previous wrongly timed insemination; b) long cycles represent late embryonic death (later than 16 d) or previous wrongly timed inseminations; and c) double cycles are mainly multiplications of normal cycles and reflects poor estrus detection.

Studying the effects of various factors on the first two cycles, we established valid statistical associations of long & double cycles with the 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 of heat detection, are largely affected by the level of the threshold, it is possible to apply different thresholds to various groups of cows.

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, as evident from a study of 2231 lactations of multiparous cows calving in six herds in the period 01/95-05/98. Odds ratio 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 were allowed for the effects of herd, year, parity, summer, calving diseases, and unobserved heat. Estimates for additional days in the rest period are presented in Table 10.

Table 10. Estimates of additional days in the rest period (3761 lactations of cows calving in 6 herds in the period 01/95-05/98) 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 August. †p<0.1, *p<0.05. **p<0.01*

Optimal Rest Period for any specific farm will be set from the break-even point of the respective effects of that factor on pregnancy rate and on days open. Other factors, such as market prices of calves and the lactation curves should be considered. The optimal length of the voluntary rest period is now reevaluated in the light of the changing pattern of the lactation curves.

Body condition score

Body condition score at calving

Body condition score at calving and the changes in **BCS** during the dry period have at times marked effects on fertility.

Table 11. Summary of multiple logistic regression analyses of fertility traits (1692 lactations in eight herds, July 1993 through June 1994). Odds ratios suffering from the trait for each additional 1.0 u **BCS** at calving.

Trait	**Unobserved heat**	**Inactive ovaries**	**Not pregnant to first AI**
Primiparous cows	0.5**	0.2**	0.8
Multiparous cows	0.9	0.4**	0.9

**p<0.05 **p<0.01*

In a study of 1692 lactations in 8 herds we found that cows calving in a higher body condition had a better fertility (Table 11). Odds ratios were adjusted to the effects of herd, summer calvings, peak yield and postparturient diseases (11). No association could be established between pregnancy rate from first service and body condition at calving, but Open Period was shorter for primiparous cows calving in a higher body condition score. The estimate for reduced days open was 6.3 days for each additional 1.0 unit of body condition score at calving. No such associations were established in multiparous cows. The effects of body condition at calving on fertility traits in our data were mainly in the first three months after calving, and they diminished with time. The results suggest that a low body condition at calving is a determinant of reduced fertility mainly by delaying the onset of ovarian activity.

Changes of body condition score during the dry period

We used data from 5908 lactations of multiparous cows in 57 herds (calving in 1996) to evaluate the effects of changes in **BCS** during the dry period on fertility (Table 12). Effects of herds, parity, season, **BCS** at drying off, and length of dry period were included in all models. Means of **BCS** at drying off and length of dry period, were 3.29±0.5 units and 65.5±9.2 days respectively. Respective rates of cows loosing or gaining ≥0.5 units in the dry period were 31.5% and 7.8%.

Table 12. Changes in the **BCS** in the dry period and fertility traits (5908 lactations of multiparous cows in 57 herds calving in 1996).

	BCS at drying off							
	Total		**≤3.00**		**3.25-3.50**		**≥3.75**	
n	5908		2289		2303		1316	
Changes in dry period	**Gained**	**Lost**	**Gained**	**Lost**	**Gained**	**Lost**	**Gained**	**Lost**
Unobserved heat[a]	0.7	1.3**	0.9	1.0	1.0	1.5**	1.1	1.3*
Inactive ovaries [a]	0.5**	1.1	0.5**	1.0	0.4	1.2	1.6	1.3
Not pregnant to ist AI [a]	0.9†	1.1	0.9	1.1	0.9	1.2	0.6	0.9
Open >150 days [a]	0.8†	1.2*	0.8*	1.3†	1.0	1.2†	1.0	1.0

*† p<0.1 *p<0.05 **p<0.01;* [a] *Odds ratio suffering from the trait*

In a recent survey (the Herd-Book set) odds ratio of cows losing ≥0.5 u **BCS** in the dry period being pregnant to first AI was 0.85 compared to rest of the cows, while their open periods were 4 days longer.

Long or short dry periods.

We used the data set of Table 12 to evaluate the effects of the length of dry period on fertility (Table 13). Effects of herds, parity, season, **BCS** at drying off and the changes in the dry period were included in all models. A longer dry period increased production, but adversely affected fertility in better-conditioned cows.

The length of the dry period, body condition score at calving, and the rate of loss of body condition during the dry period are closely related. It is important to establish their independent effects on postparturient performance. In our studies, a longer dry period was determinant to culling, ketosis, and fertility but increased milk yield.

Table 13 The length of the dry off period, fertility traits and production in relation to **BCS** at drying off (effects of additional 1 day dry period)

	BCS at drying off			
	Total	**≤3.00**	**3.25-3.50**	**≥3.75**
n	5908	2289	2303	1316
Unobserved heat [a]	1.00	0.99	1.00	1.01
Inactive ovaries [a]	0.99*	0.99	0.98	0.97**
Not pregnant to first AI [a]	1.01**	1.00	1.02**	1.01†
Open >150 days [a]	1.01**	1.00	1.02**	1.01*

*† p<0.1; *p<0.05 ; **p<0.01* [a] *Odds ratio suffering from the trait*

In a recent survey (the Herd-Book set) odds ratio of cows calving after 70 days dry period being pregnant to first **AI** was 0.87 compared to those after 60 to 70 days, while their open periods were 3 days longer.

Summer calvings

The negative effect of the summer on fertility under the Israeli conditions could be heavy. Although this factor reflects any effects associated with the summer, we assume that climatic effects (heat stress) are the main ones. We found from data of 109 herds in 1993, transferring 1% of the cows in the Israeli National Herd from winter to summer calving was associated with additional 17 days open for each cow in the country.

Results in the individual farm should be interpreted in the light of the following considerations: a) Quotas. Many farms with extra production potential, direct cows to calve in the summer due to the season differential pricing of milk. Additional income should be weighed against loss of milk. b) Financial returns from investment in better housing, shading and cooling systems.

"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. More variables added to the models less unexplained residuals will be left. When the complete model of "contribution to non-pregnancy" was applied to 144 farms, 10 to 11% of the "total non-pregnancy" could be explained (Table 14).

Table 14. Mean contribution of variables in the model of "non pregnancy to first service" to total non-pregnancy

Lactation:	**First**	**Second**	**≥Third**
Total not-pregnant (%)	57.9	64.7	66.4
Total explained by the model	10.5	10.7	11.6

From manual observations to automation

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 dairy cows in various stages of the lactation is the most important tool used to evaluate 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). Afiscale© is an automated scale, which is an integrated part of the Afimilk© system. We use body weight (**BW**) data derived from the Afiscale© in our 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 stand as a single measurement. Table 15 compares two multiple logistic regression models for ketosis after calving, in data taken from 1424 lactations in eight different herds. The models evaluate the effects of established risk factors on ketosis; the two models differ from each other in one of the risk factors (**BCS** ≥3.75 units and the highest quarter of **BW** at drying off respectively). The two models show similar results.

Table 15. Summary of multiple logistic regression analyses for ketosis (1424 lactations of multiparous cows in eight Afifarm herds.

	Summer Calvings	**Dry period >70 days**	**Calving diseases**	**BCS ≥3.75**	**BW[b]**
Odds Ratio[a]	1.7**	1.1	3.1 **	2.3**	
Odds Ratio[a]	1.6**	1.3	2.7 **		3.9**

$**p<0.01$; [a]to suffer from ketosis compared to a cow without the examined factor; Effects of parity were included; [b]Body weight at drying off over 718 kg (upper 25%tile)

Efforts to develop other automated substitutes to manual data are going on; On line analysis of milk fat and protein is now in possible and will allow for better diagnosis and decision making as explained in the following two examples.

The relationships between ketonuria & fat/protein ratio in the first test

Indication as to the relationships between ketonuria & fat/protein ratio in the first test may be obtain from the observation by Cohen (12) who examined all calving cows in an Israeli herd for ketonuria as part of the routine postparturient examination carried out between 5 to 12 **DIM**. Although the first milk tests took place from four to 25 **DIM** and were not related to the postparturient examination, a clear association between fat/protein ratio >1.40 and ketonuria is evident (Table 16).

Table16. The association between fat/protein ratio in the first test and ketonuria in 458 cows calving in one Israeli herd in the period 07/03-06/04 (Cohen, 2004).

Fat/protein ratio[a]	**≤1.207**	**1.207-1.318**	**1.319-1.474**	**≥1.475**
n cows	115	114	114	114
% of ketonuria	16.5	21.7	21.7	41.2

[a]Values are of the four quarters respectively

The association between fat to protein ratio in the first milk test and loss of body weight (BW)

In a sample of three herds with Afiscale© with 846 valid observations out of 1642 lactations, means of **BW** were obtained for each 5 days period of days in milk (**DIM**)**,** i.e. 1 to 5, 6 to 10, 11 to 15, 16 to 20, 21 to 25, 26 to 30. **Fat/protein** ratios were calculated for each period if test was within period or 2 days following the end of the period. Changes in **BW** were calculated either in absolute values or as percentages **BW** of the previous periods respectively. **Fat/protein** values of >1.4 in the periods+2 days were the **gold standard** for negative energy balance. The statistical analysis of the data is presented in Table 17.

Table 17. The relationships between fat/protein ratio in the first test to loss of **BW** (846 lactations in 3 herds)

	Lost 20 kg	**Lost 10 kg**	**Lost 3% BW**	**Lost 6% BW**
% in population	17.1%	45.9%	25.8%	3.6%
n cows	145	388	190	26
% with f/p>1.4[2]	35.1%	27.3%	33.7%	42.3%
Coefficient[1]	0.86954***	0.61912***	0.84265***	0.96606*
sensitivity	28.7%***	59.6%***	36.0%***	6.2%**
specificity	85.9%***	57.8%***	81.1%***	97.8%**

*[1]All stepwise logistic regression models also included the effects of herds, parity, & DIM; [2]Rate of trait in the population was 21.0%   *p<0.05 ***p<0.0001*

Other progress in automation is expected in the ability to analyze on line somatic cell counts, progesterone and ketones, optic measurements of **BCS** of cows and body height of heifers.

Multidisciplinary causal analysis

The Israeli **ECM** formula rewards both high milk protein and high milk fat contents. In the discussion that followed the presentation of the results of a Herd Report to the farmer and the nutritionist, neither was aware of the adverse effect of feeding fresh cows for high milk fat contents on health. The nutritionist insisted nevertheless, that no changes should be made in the ration to prevent the expected negative effects on the **ECM** yield. He also made the point that *"…herdsmen should be warned against a tendency to lower the efforts aimed at improving milk fat contents*". Such a state, where the relationships among production, fertility and health have been so unbalanced, could not be accepted by the veterinarian, the final decision was left in the hands of the farmer. This, not atypical example, serves to show the inherent difficulties associated with multidisciplinary advices. The introduction and assimilation of systems approaches into the education of animal and veterinary scientists, and the development of whole herd models talking into account production, health and fertility will be essential to achieve a better multidisciplinary balance in the future. This urgent need is not easy to satisfy, considering the present state where models evaluating health are based on **within herd**, while those evaluating nutrition on **among herds'** differences.

Conclusions

Routine health reports based on epidemiological models are today 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 a) improvement of data through automation; b) development of multidisciplinary models including economical evaluations and c) improvement of methods applied to small herds.

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