Management of Heat Stress to Improve Fertility in Dairy Cows in Israel

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Abstract

Israel has about 100,000 dairy cows mostly all of *Israeli-Holstein*-breed, kept in close to 1,000 dairy farms. Most farms are distributed along the Mediterranean Sea coast and in the hot internal valleys. According to the Israeli Herd book the average annual milk production, per cow in 2008 was 11,460 kg, with 3.7% fat and 3.2% protein. Israel's climate is considered "subtropical dry" or Mediterranean, characterized by warm and dry summer with day temperatures above 30^{o}C and relative humidity ranging from 50% to 90%. Climatic limitations brought dairy farmers to develop and implement new technologies and management practices that would enable high milk production and reproduction in summers. In the last three decades the Ministry of Agriculture research units, the extension service and dairy farmers conducted a series of trials and surveys in order to develop an efficient cooling system that will obtain and maintain high milk yield and good reproduction during the hot and humid summer. The cooling system commonly used in Israel is based on a combination of frequent direct watering of the cows, followed by forced ventilation air blowing onto the cows. The system was developed in Israel nearly 30 years ago. A typical cycle is five minutes long and consists of 30 seconds of watering followed by 4.5 minutes of forced ventilation. Providing the cows with 5-7 cooling sessions per day, 30-45 minutes each, allowed cows, producing 25-30 kg of milk per day to maintain their body temperature below 39.0 C, throughout the day time, on a typical Israeli summer day. At the same time, non-cooled cows had high body temperatures (above 39.5C), during some part of the daytime and returned to normal body temperatures (below 39.0C), only for a few hours late at night. In an experiment conducted in 1985-86, conception rate (CR) of cows, cooled as described above, was significantly higher than of non-cooled cows (59% Vs. 17% and 57% Vs. 17%), for first insemination and for all inseminations, respectively. Pregnancy rate (the amount of pregnant cows out of the eligible cows in the herd) calculated for 90, 120 and 150 days after calving differed significantly between the groups, (44%, 59% and 73% Vs 5%, 11% and 11%), in cooled and non-cooled cows, respectively. CR and pregnancy

rates obtained in intensively cooled herds in this experiment were similar to those obtained during the winter of that year, in commercial dairy farms in Israel. Differently from the results described above, when cows in summer were intensively cooled, only for a period of 2 days before and 8 days after A.I, CR failed to improve (31% and 36%), in cooled and non-cooled cows, respectively. These results offer a conclusion that cows must be intensively cooled and must maintain normal body temperatures during the entire day and during the whole summer. i.e. the entire reproductive process from follicular development until implantation of the embryo in the uterus, in order to express cow's full reproductive potential in Israeli summer conditions. The effect of cooling intensity on cow's productive and reproductive traits was studied in a wide survey, during four consecutive years (1998 –2001), on 14 farms, averaging 300 milking cows each, all located in the coastal plain of Israel. Farms were categorized into three different groups according to the intensity of summer cooling. "Intensive" (7.5 cumulative cooling hours per day), "Moderate" (4.5 cumulative hours per day) and "No- cooling" at all. CR was 56%, 53% and 54%, and 40%, 34% and 15%, for primiparous ($P<0.01$) and 47%, 46% and 43%, and 34%, 34% and 17% for multiparous cows ($P<0.01$), in the "intensive", "moderate", and "no cooling" groups, in winter and summer, respectively. In another survey based on the Israeli Herd Book data from 2005, using elite yielding herds (with average annual milk production per cow of more than 13,000 kg), the average CR of intensive cooled herds was 39% and 19%, in winter and summer respectively, compared to 39% and 12%, respectively, in non-cooled high yielding herds ($P<0.01$). This indicates that intensive cooling in summer can reduce by half the summer drop in CR, even in very high yielding herds. The Ministry of Agriculture extension service, in cooperation with the Israel Cattle Breeders Association (ICBA), developed a computerized report called "Summer to Winter (S:W) Performance Ratio", based on the "Israeli Herd book" data from more than 300 herds. The higher the ratio is for productive and reproductive traits, the better a farm handles summer negative effects on cow's performance. Based on the S:W ratio of each herd in 2007, we quantified the overall effect of intensive cooling in summer on the cow's whole year performance. Data from

24 farms with the highest S:W ratio were compared with data from 24 farms with the lowest S:W ratio. The comparison showed that well cooled cows in Israeli summer added approximately 700 kg of milk to cow's lactation, an increase of 6.5% in its annual production. Summer CR were significantly higher in the highest S:W ratio farms, compared with the lowest ones (27% Vs 19%), and compared to those obtained in same groups in winter (40% Vs 36%), respectively. High S: W ratio herds reached in summer conception rate of 70% of their winter CR, compared to only 50% in the lowest S:W ratio farms inseminated in same period. Trials conducted in the last 10 years show clearly that intensive cooling of high yielding cows (above 45 kg daily) in summer cannot completely eliminate summer decline in CR (as was achieved two decades ago when daily production was less than 30 kg). These high yielding cows despite being intensively cooled could not maintain normal body temperature all day long. This fact brought Israeli researchers to look for hormonal treatments to improve cow's summer fertility, among them elevating post insemination blood progesterone, GnRH treatment at time of insemination to optimise insemination time, improvement of egg quality by elimination of aged follicles produced during heat stress and the use of timed AI and embryo transfer. Part of these treatments improved summer CR when combined with intensive cooling.

Cooling Intensification combined with hormonal therapy, management and nutritional practices are expected to minimize the gap between summer and winter CR obtained in Israel in the future.

Key words: summer, fertility, heat stress, cooling cows, conception rate.

Introduction

Israel is located to the east of the Mediterranean Sea. Israel's climate is considered subtropical and dry. The climate is characterized by moderately cool, rainy winters (November–March) and hot, dry summers (June–October) with no rainfall. Summer is

warm and humid along the coast (daytime temperatures average 30 ^{o}C and the relative humidity is from 50 - 90 %), but hot and dry in the inland valleys and southern desert (daytime temperatures average above 40 ^{o}C and the relative humidity in between 20 and 40 %).

The Israeli dairy sector consists of 100,000 *Israeli-Holstein* cows on 1,000 dairy farms. These farms are distributed mostly on the coast and in the hot valleys. Based on the Israeli herd book data (DHI), which includes nearly 90 % of the dairy cattle, the 2008 average annual milk production was 11,460 kg per cow, with 3.71 % fat and 3.20 % protein.

The Israeli dairy sector is divided into 2 main sub-sectors. Cooperative, relatively large dairy herds (above 300 cows per unit), representing 62.2 % of the cows with recorded production that predominantly participates in DHI milk recording. All cooperative dairy farms milk 3X and their average milk yield in 2008 was 11,862 kg/cow, with 808 kg of fat + protein/cow/year. Approximately 75 % of the relatively small family dairy farms (40 - 100 cows per unit) participate in the DHI system and represent 37.8 % of the cows with recorded production. Nearly half of the family dairy farms milk 3X and the remainder milk 2X. Average milk yield in 2008 for family dairies was 10,794 kg/cow and the average production of fat + protein was 737 kg/cow/year.

Dairy farmers in Israel are well-organized and supported by professional institutions related to the Ministry of Agriculture, universities, milk marketing board, and farmer's cooperative companies who supply clinical veterinary care ("Hachaklait") and AI services ("SION"). Israel Cattle Breeders Association (**ICBA**) owns the local DHI

services, based on automatic data flow from the computerized milking equipment. These on-line reports, elaborated on by the DHI, with a special Dairy Herd Management program (**NOA**), enable Israeli dairy farmers to make operational decisions and manage their farms efficiently.

In the early stages of development of the dairy sector, special production conditions led Israeli dairy farmers to establish a unique and unconventional production concept. This concept was characterized by special and intensive feeding and management practices with cows living in total confinement and on relatively large dairy farms. The strategic decision, made years ago, was based on the belief that, under Israel's special conditions, a maximization of milk production/cow would be the most economically viable. Climatic limitations forced dairy farmers to develop and implement new technological solutions and special management practices to attain high milk yields in the hot and humid summers.

Almost all dairy herds use electronically controlled milking equipment, most of it, manufactured by two Israeli companies (AFIMILK and SCR). Based on the parameters collected through electronic monitoring during milking, daily milk production is recorded and heat detection is determined from data captured with "Leg-tags" (AFIMILK) or "Neck-tags" (SCR). All dairy farms use electronic heat detection data, when inseminating their cows and only part of them supplement that data with visual observation 2-3 times a day. An increasing proportion of the farms, typically the large ones, rely completely on electronic heat detection when inseminating their cows.

The constant rise in milk yield/cow are boosting milk production and decreasing cow's reproductive traits. During the last 3 decades, Israeli researchers have developed an efficient cooling system, which enables high milk yields and better fertility during the hot season. The technologies for cooling cows have been rapidly adopted by Israeli farmers. Incentives provided by an appropriate pricing system for milk, have encouraged dairy farmers to install and use these systems extensively. To achieve positive results, proper installation and accurate operation of the cooling system is required.

Seasonality in milk supply to the processing industry and market is one of the factors that most influences Israel's dairy sector economy. Due to climatic effects, summer milk production does not meet the market demand; therefore, winter surpluses are *moved* to summer consumption. Every year, nearly 40 million liters of milk are *moved* in Israel from winter to summer, with an additional annual cost of 8 million US$ (0.2 US$ per liter). In addition to the large economic losses, seasonality in milk supply creates a *political* problem, causing constant pressure on the government to replace these *missing liters*, by importing low priced milk powder; a step that can affect the local farmer's quota and their annual income. The low reproductive rates, achieved in summer and the suspected indirect effect of summer conditions on winter reproductive potential, as was previously speculated, are key factors influencing the seasonality of the milk supply, particularly during the summer marketing period.

Results and Discussion

The cooling system predominately used in Israel is based upon the combination of wetting the cows frequently followed by blowing air on them with forced ventilation.

This system was developed and first implemented in Israel through cooperation between the Department of Animal Science of the Hebrew University of Jerusalem and the Extension service of the Israel Ministry of Agriculture. The system was first described more than 20 yr ago [1]. Cooling the cows 5 times a day, 30 min each time, allowed cows producing 25-30 kg of milk/day to maintain their body temperature below 39.0 °C, throughout the entire day in a typical Israeli summer.

Based on the Israeli Herd book data, between 1994 and 2008, winter conception rate for the first 2 inseminations dropped 15 % (from 45 to 38 %) on large scale herds, compared to a decline of 30 % (from 48 to 35 %) on small scale farms. Summer conception rates were almost unchanged on the large scale herds (from 21 to 20 %), but declined significantly on the small scale farms (from 22 to 13 %). Significant increases in daily milk production and less implementation of cooling systems can partially explain the results obtained on the small scale farms; while on the large scale farms, known to have better implementation of cooling systems; most of the decline in annual conception rate can be attributed to that which occurred during the winter months. We suggest that significant increases in summer per cow daily milk production, and especially lactation peaks, recorded in recent years on both farm sizes with the resultant effect on the cow's metabolic status and accumulation of body reserves, could have negatively affected the conception rates in the winter and throughout the year. This phenomena needs to be further investigated, if better reproductive results are desired.

Conception rate to first and all inseminations was studied in cows, cooled with the same procedure 7 times a day [2]. Intensive cooling allowed cows, producing 30 kg of

milk/day to maintain normal body temperature (≤ 39.0 °C) both day and night. In the same study, non-cooled cows had high body temperatures (≥ 39.5 °C), daytime significant portion of the day and returned to normal body temperatures (≤ 39.0 °C), for only a few hours during the late night. The conception rate of intensively cooled cows was significantly higher than that of non-cooled cows (59 Vs 17% and 57 Vs 17 %), for first and all inseminations, respectively. Pregnancy rate calculated for 90, 120 and 150 d postpartum differed significantly between groups (44, 59 and 73 % for cooled Vs 5, 11, and 11 % for non-cooled). Conception rates and pregnancy rates, obtained in intensively cooled cows in this experiment, were similar to those obtained in that same winter on commercial dairy farms in Israel.

One more study completed in the same timeframe by our group [3], showed that intensively cooling cows in summer, for a period of 2 d before and 8 d after A.I, did not improve conception rate (31 and 36 %), for cooled and non-cooled cows, respectively.

From the results obtained in these experiments, we concluded that intensive cooling of cows producing around 30 kg/day, which allows them to maintain normal body temperature throughout the entire day and summer, can result in similar conception rates in winter and summer. Intensive cooling cows, for only a short time, near the time of insemination, did not yield the same results; probably because the *damage* caused by heat stress occurred before or after this short period. We assume that intensive cooling and normal body temperatures are probably needed throughout the entire summer, covering all the reproductive steps (from initial follicular development, through implantation of the

fertilized ova in the uterus), in order to maintain the cow's reproductive potential under Israeli summer conditions.

It is now time to mention that, in measurements carried out recently, cows producing 45-50 kg of milk/day that were cooled in the same intensity, were not able to maintain their normal body temperature throughout the day, as did cows in the study [2]; although they were exposed to similar climatic and cooling conditions. Cows which were cooled for 45 min every 3 hr, could not maintain normal body temperature between cooling treatments. Furthermore their body temperature tended to increase and be elevated for at least 1 hr before the next cooling treatment. We expect that due to this phenomenon, these cows faced at least 5-6 periods of approximately 1 hr duration during the day, when their body temperature exceeded 39.0 °C. In the last decade we conducted surveys in cooperation with the ICBA. The aim of these studies was to evaluate the effect on productive and reproductive traits of high yielding cows where the cooling systems are installed on commercial farms located in different parts of the country.

The first survey studied the effect of cooling intensity on cow's productive and reproductive traits. This large scale survey was carried out during a 4 yr period (1998 – 2001) and included 14 farms, with nearly 300 cows each, located in the coastal region of the country [4]. Farms were classified into 3 different groups according to the intensity of cooling in summer. Cows in group 1 (6 farms, intensive cooling), were cooled in the holding and feeding area for a total of 10 cooling periods and 7.5 cumulative hr/d. Each cooling period combined cycles of sprinkling (0.5 min) and forced ventilation (4.5 min). Cows in group 2 (3 farms, moderate cooling), were cooled in the holding area only, and

were provided a total of 6 cooling periods and 4.5 cumulative hr/d. Cows in group 3 (5 farms, no cooling) were not cooled at all. Milk production (kg/d) and conception rates (%) were calculated for summer (July-September) and winter (December- February). The analysis included 125,000 milk recordings (> 5 recordings for each cow/lactation) and 17,000 inseminations. The average daily low and high temperatures were 8.4 and 19.3 °C in the winter and 22.0 and 31.8 °C in the summer for the 4 yr period. The interaction between season and cooling treatment was significant ($P < 0.001$). The ratios between summer and winter daily average milk production for first calf heifers were 98.5, 96.2, and 93.4 % in intensive, moderate, and no cooling treatments and for adult cows were 98.5, 96.1, and 90.7 %, respectively. Conception rates were 55.8, 53.5, and 53.9 %, and 40.4, 34.0, and 14.6 %, in the summer for first calf heifers under intensive, moderate, and no cooling treatments, respectively ($P < 0.01$). In the winter, conception rates were 46.6, 45.8, and 43.5 %, and in the summer 33.8, 34.5, and 16.7 % for adult cows in the same cooling groups ($P < 0.01$). These results (Table 1) indicate that intensive cooling of cows in the summer has the potential to reduce the seasonal variations in productive and reproductive traits by half. (Table 1)

The second survey attempted to determine if intensive cooling had the potential to prevent summer declines in milk production and reproduction of extremely high yielding cows (annual herd average ≥ 13,000 kg). The survey used 2005 ICBA herd book data and included 22 dairy herds, averaging 300 cows each, for a total of 6600 cows [5]. All dairy herds were located in the coastal region of Israel. Cows in all the herds were maintained in similar housing systems, milked 3x and fed for ad-lib intake. Twelve of the

herds were designated as high and 10 low production level based on the previous year's winter Economical Corrected Milk (**ECM**) yields (average 41 and 35 kg/d, respectively). Cows in half of the herds in each production level group were intensively cooled (**IC**) during summer, using a combination of wetting and forced ventilation for 10 cooling periods and a total of 7 cumulative hr/d. Cows in the second half of the herds in each production level group were moderately cooled (**MC**) by a combination of wetting and forced ventilation in the holding pen, only before milking (the minimum cooling found these days in Israeli commercial herds).

Winter (Jan-Mar) and summer (Jul-Sept) ECM production averaged 41.5 and 40.7 kg/d, respectively, for the IC herds; and 38.5 and 33.8 kg/d, respectively, for the MC herds in the high production level. During the same seasons the low producing herds ECM production averaged 36.5 and 36.8 kg/d, respectively, for the IC herds, and 34.4 and 30.2 kg/d, respectively for MC herds. Conception rate for the first and second insemination performed in winter and summer averaged 39 and 19 %, respectively, for the IC herds and 39 and 12 %, respectively, for the MC high producing herds (Table 2).

Results show that intensive cooling of high yielding cows during the summer reduced the decline in CR by about half, even in extremely high yielding cows.

Through the years we, as an Extension service, found the necessity to create a tool that permits us to monitor the effectiveness of cooling systems installed on farms [6]. In cooperation with ICBA, we developed a computerized report (based on the information stored in the "Israeli Herd Book") which evaluates the effectiveness of the cooling system for individual farms on reducing the impact of summer on cow's performance. The

"Summer to Winter (S:W) Performance Ratio" report utilizes the farm's monthly recorded data for milk, milk fat, milk protein, somatic cell counts (**SCC**), and conception rate. The higher the ratio (close to or ≥ 1.0) for productive and reproductive data and the lower the ratio for SCC data, the better the farm is dealing with summer heat stress. The calculations included in this report estimate the LSM for milk yield and ECM (kg/d); fat and protein (%); SCC (000/ml); and summer and winter conception rates (%) for the 2 seasons, followed by a calculation of S:W ratios.

In 2005, S:W ECM ratios ≥ 0.96, 0.90 to 0.96, and ≤ 0.90 were recorded in 34, 44, and 22 % of the dairy farms in Israel respectively. Summer : Winter ECM and CR ratios were 0.95 and 0.37 in the 495 small scale family farms averaging 50 cows each; and 0.93 and 0.53 in 191 large scale cooperative farms averaging 300 cows each, respectively. High, middle, and low producing herds (mean winter ECM yields of 35.2, 33.1 and 30.2 kg/d, respectively), had S:W ECM ratios of 1.03, 0.93 and 0.82; and their S:W CR ratios were 0.63, 0.51, and 0.38, respectively. The S:W production ratio was above 0.96 for 70 % of the farms located in mountain region, compared to only 30 % of the farms located in the extremely hot regions.

A summary of the results for productive and reproductive traits and their S:W ratios are presented in Table 3.

The data presented indicates that high producing herds (probably having better management) also obtain better productive and reproductive results in summer. The computerized report can provide data analysis both on a regional and individual farm

basis; enabling the detection of farms that need to improve summer management and guiding the provision of necessary consultancy and follow-up by extension advisors.

Based on the S:W ratios from the 2007 report, recently we tried to quantify the overall effect of the better management provided by dairy farms that intensively cool in the summer on their annual productive and reproductive results [7]. Summer to winter ECM ratios for each herd served as the parameter by which we designated the 24 top farms in Israel and compared them to the 24 farms with the poorest results. We assumed that the difference between the productive ratios of these 2 groups represented the total effect of cooling and better summer management on their annual yield and reproduction traits. The average herd size of farms in the study was 400 cows, so the comparison includes near 10,000 cows in each group. Initial averages for productive and reproductive traits for the "high" and "low" ratio groups are presented in Table 4.

The fact that the average winter milk production was similar in both groups supported the supposition that most of the differences in the S:W ratio among farms in the 2 groups can be related to better management in the summer in the high ratio group.

Least square means for Milk, ECM, milk fat, and milk protein for 305 d lactations for high and low S:W ratio farms are presented (Table 5). The data indicated that intensive cooling of high yielding dairy cows under Israeli summer conditions had the potential to add approximately 700 kg ECM to every cow's lactation, an increase of 6.5 % in annual production. Cows in high ratio herds that calved in spring and early summer reached higher lactation peaks while those calving in winter had more persistent lactations compared to cows on low ratio.

Farms; probably due to being intensively cooled in summer.

In general, we ultimately noticed that Israeli cows tend to have much better lactation persistency today compared to lactations recorded 2-3 decades ago. No doubt, the use of cooling systems in a high proportion of farms in recent years has been one of the factors influencing this phenomenon. When comparing annual reproductive traits between high and low ratio farms, we found no difference in the proportion of short, normal, long, and double insemination cycles between high and low ratio farms in both seasons (7, 56, 13, and 24 %, respectively). Unlike the winter months, summer CR were significantly higher in the high ratio farms, compared to the low ones (40 Vs 36 % and 27 Vs 19 % for winter and summer, high and low ratio farms, respectively (Table 5). Conception rates in the high ratio herds were nearly 70 % of the winter level; while low ratio herds reached only 50 % of the winter conception level [7]. Results differed from those in milk production in that intensive cooling did not eliminate the entire decrease in summer CR on high S:W production ratio farms.

Researchers in the Animal Science Department of the Hebrew University, Jerusalem have worked for more than 2 decades in developing hormonal treatments to improve cow's summer fertility.

Among these treatments one can find the following:

- Efforts to manipulate blood progesterone after insemination to support pregnancy,
- GNRH treatment at time of insemination to improve timing between ovulation and insemination,

- Improvement of ovum quality through hormonal treatment to eliminate aged follicles produced under heat stress conditions, and
- Implementation of timed AI and embryo transfer technologies in the summer.

Many of these treatments were found to improve summer conception when combined with intensively cooling the cows.

We expect, therefore, that future improvements in the fertility of Israeli cows will probably include the combination of improved and intensified cooling treatments with the above mentioned hormonal treatments. In parallel to further development of these methods, an economic evaluation of cost-effectiveness of these improvements under Israeli conditions will have to be conducted.

Conclusions

The data presented herein regarding Israeli herd brings us to the following insights:

Although obtaining relatively high yields, while producing under limiting climatic conditions, the herds obtain relatively fair reproductive performance.

The fact that many of the cows are inseminated based mostly or only on electronic heat detection, does not limit the Israeli dairy farms from obtaining normal insemination and conception rates.

Intensively cooling cows in the summer has the potential to totally eliminate the summer decline in milk production. This positive effect can be achieved in commercial dairy farms, even on extremely high yielding farms.

Under experimental conditions, intensive cooling of cows that produce nearly 30 kg of milk daily in the summer (7 cooling treatments/day) allowed maintenance of normal body temperature throughout the day, all summer. Conception rates obtained in the summer were similar to those obtained in winter.

Intensive cooling of cows producing nearly 50 kg of milk daily, using the same system and under the same conditions, did not allow cows to maintain normal body temperature throughout the day. Cows had 5 - 6 periods during the day of approximately 1 hr duration, in which their body temperatures were above normal.

Proper managing and intensively cooling high yielding cows in the summer (high summer to winter production ratio) reduces the decline in summer conception rate to only in half.

It appears that, obtaining *winter conception rates* in summer through intensive cooling of the cows can be attained only if cooling maintains normal body temperature throughout the entire day and summer.

Some hormonal treatments have the potential to improve summer fertility, especially when combined with intensive cooling of the cows.

There is a need for an economical evaluation of the cost-effectiveness of further intensification of cooling the cows and/or the use of hormonal treatments to improve summer fertility under Israeli conditions.

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Table 1. Effect of different intensities of cooling cows by a combination of wetting and forced ventilation on their productive and reproductive traits.

Parameter	Treatment		
	Not cooled	Cooled in holding pen	Cooled in holding pen + feed line
Cooling (hr/d)	0	4.5	7.5
Summer decline in milk production, kg/day	3.6[c]	1.6[b]	0.6[a]
Summer : Winter production ratio, %	90.7	96.1	98.5
First insemination CR – winter, %	54[a]	53[a]	56[a]
First insemination CR – summer, %	15[c]	34[b]	34[b]

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Table 2. Effect cooling intensity in summer on average corrected milk production (kg/d) of dairy cow located in farms with high and low production level.

	Level of production

Cooling intensity	High		Low	
	Intensive (IC)	**Moderate (MC)**	**Intensive (IC)**	**Moderate (MC)**
Winter ECM, kg/d	41 - 43	38 - 40	35 - 38	33 - 36
Summer : winter production ratio	0.96 – 1.00	0.86 – 0.88	0.97 – 1.03	0.84 – 0.90
Average ECM production, kg/d				
Winter	42.0	39.1	37.1	35.3
Spring	42.3	39.2	39.1	36.2
Summer	42.0	35.7	38.0	32.0
Autumn	42.1	36.9	38.1	34.1
Conception rate, %				
Winter	39	39	40	39
Summer	19	12	25	3

Table 3. Effect of production level on summer to winter ratios for economical corrected milk (ECM) and conception rate (CR) of all Israeli herds (2005).

Parameter	Production level		
	High (Top 25 %)	Medium (Middle 50 %)	Low (Low 25 %)
Winter ECM production, kg/d	35.1	33.2	30.2
Summer ECM production, kg/d	36.1	30.9	24.8
S:W ECM ratio	1.03	0.93	0.82
Winter CR, %	41	41	41
Summer CR, %	27	20	14
S :WCR ratio	0.66	0.49	0.34

Table 4. Summer and winter averages of economical corrected milk (ECM) and conception rate (CR) for first 3 inseminations and their ratios in high and low ratio herds.

Parameter	Group	
	Low S : W ratio	High S : W ratio
No. Herds	24	24
Winter Milk Production kg/d	39.5	39.7
Summer Milk Production kg/d	34.4	38.9
S:W ECM ratio	**0.87**	**0.98**

Winter Conception Rate %	0.36	0.40
Summer Conception Rate %	0.19	0.27
S:W ratio	0.53	0.68

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Table 5. Average 305-d production for milk, economically corrected milk (**ECM**), milk fat, and milk protein for herds with high and low S:W ratio.

	Group			
	Low S : W ratio	High S : W ratio	Difference (kg)	Added production (%)
Milk, kg	11,346	12,017	671	6.0%
ECM, kg	11,081	11,807	726	6.5%
Milk, kg	402.6	430.1	27.5	6.8%
Milk protein, kg	360.9	385.3	24.4	6.8%