REPRODUCTIVE AND MILK PRODUCTION PERFORMANCES OF SIKHIO DAIRY COOPERATIVE SMALL HOLDER FARMS

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Abstract

The objectives of this research were to investigate RP and MPP indices of smallholder farms operated under Sikhio Dairy Cooperative (SDC), Nakhon Ratchasima, Thailand. A cross-sectional study of questionnaire and focus-group interviews were performed on 55 out of the 63 SDC farm owners to analyze socio-demographic, farm management, level of cooperation with SDC. A database analysis was conducted on their 195 dairy cows during the visits, to include age at first service (AFS), age at first calving (AFC), service per conception (SPC), conception rate at first service after calving (CFSC), calving to calving interval (CCI), calving to conception (CTC), daily milk yield (DMY), lactation milk yield (LMY) and lactation length (LL). The result showed most respondents were between 20-40 years old with the highest level of education of a bachelor's degree. Their farming experience varied among less than 5 years, 5-8 years, and more than 8 years at 32.73%, 47.27%, and 20.00%, respectively. Their SDC membership length also varied. All farms raised Holstein Friesian crossbreed cattle. All participants were considered as small-medium size (about 60% lactating cows, 16% dry cows, and 24% replacement heifers). The AFS, AFC, SPC, CFSC, CCI and CTC were 21.1 months, 32.7 months, 2.41 times, 56.6%, 436 days and 118 days, respectively. Average DMY, LMY and LL were at 13.4 kg/day/cow, 3,766 kg/lactation/cow and 317 days, which met the acceptable expectation set by Department of Livestock Development. The result indicated SDC members achieved effective MPP, but high AFC, SPC, CCI, CTC suggested substandard RP in postpartum problems and replacement heifers. In addition, farming experience ($P<0.01$) and level of cooperation with SDC ($P<0.05$) had significant positive correlation with MPP. With challenging variables presented in Nakhon Ratchasima, SDC farms still yielded satisfactory productivity, revealing SDC networking to be beneficial to smallholder farm productivity.

Keywords: Dairy cooperative, Reproductive performance, Milk production, Sikhio, Smallholder farms

Introduction

Effective reproductive performance (RP) and milk production performance (MPP) are key indicators of dairy farm sustainability (Munyaneza et al., 2019, pp. 149-152). RP is hindered when cows cannot reach estrous, conceive, deliver a calf annually, or optimize MPP (Kim & Jeong, 2019, pp.523-525). Other challenges such as diseases, unavailability of breeds, reproductive disorders, or deficient nutrition can limit milk production (VanLeeuwen et al., 2012, pp. 235-236). The Thai government and the Department of Livestock Development (DLD) initiated a dairy farm cooperative system in 1986 to alleviate these challenges (Chantalakhana & Skunmun, 2002, pp.15-20). Outside of public services, smallholder farms are deprived of resources commonly available to competitors within the industry, thus they seek assistance from cooperative institutions to overcome and survive. Cooperative support provides adequate income (through dividend and insured sales) and competitiveness (through membership-priced logistics and livestock health care aid). Further, cooperative membership provides the opportunity to share innovations tested and proven by peers (Saengsanga & Rattana, 2018, pp.61-63).

About 71% of Thai dairy farms are smallholders operating with an average of less than 30 cows/farm (Aiumlamai, 2009, p. 11). There were reports on RP and MPP in different regions and environmental conditions throughout the country, but there is yet a definite analysis on northeastern smallholder farms operating under a cooperative system. The Sikhio Dairy Cooperative (SDC), situated in Nakhon Ratchasima, integrated 63 smallholder farms that nurture dairy cows under the intense heat of Northeastern Thailand. SDC's performance is ranked as one of the top districts to satisfy the annual demand with a smaller average number of cows (Nakhon Ratchasima Provincial Livestock Office, 2022), hence they were chosen for this study. This study shall provide an insight into northeastern cooperative farms operations, which may enhance profitability and sustainability for other smallholder farms interested in cooperative system.

Research objective

The study aimed to investigate dairy cow RP and MPP by farms operated under the SDC.

Research methodology

Description of the study area

This study received an approval of ethical clearance from the Institutional Ethics Committee, NRRU, Thailand (Approval No. HE-132-2020). A cross-sectional study was performed on SDC members in Sikhio, Nakhon Ratchasima, Thailand. The area is located at 14°53′30″N latitude and 101°43′24″E longitude, at an altitude of 150-300m above sea level. The area receives an average annual fall of 107 cm and an overall average temperature of 27.3℃.

Sampling procedure and data collection

A sample of 55 out of 63 SDC members were selected with a 95% confident level using the sampling formula by Yamane (1967). The owners of the farms responded to the research questionnaire between November 2020 and January 2021, and also took part in the focus-group interview, providing primary data that include socio-demographic (gender, age, education level and farming experience), farm management (own fodder, farm size, cow culling, heifer replacement, diseases, and AI), and the level of cooperation (unwilling, limited, partial, full) with SDC. Farm visits were conducted to discuss additional information such as land partition, fodder management or disease control. The SDC database (IService^{+}) provided secondary data, including farm records, official publications, and enumerated RP indices [age at first service (AFS), age at first calving (AFC), service per conception (SPC), conception rate at first service after calving (CFSC), calving to calving interval (CCI), calving to conception interval (CTC)],] and MPP indices [daily milk yield (DMY), lactation milk yield (LMY) and lactation length (LL)] of 195 cows from the previous 3 production years.

Data analysis

Data analysis was conducted by descriptive analysis, including mean, median, standard error of the mean (SEM) and percentages using the SPSS application version 20.0 by the SPSS Institute, Inc., Chicago, IL, USA. The Pearson's test was used to determine correlations between the primary data and the secondary data. A $P<0.05$ indicated statistically significant.

Results

Farmers' socio-demographic and farm management

Most respondents were between 20-40 years old. Many were deprived of basic education and only 3.64% obtained a bachelor's degree. 47.27% of the members had 5-8 years of farming experience, with 20% started at least 12 years prior. The level of cooperation between SDC and the members also varied (Figure 1).

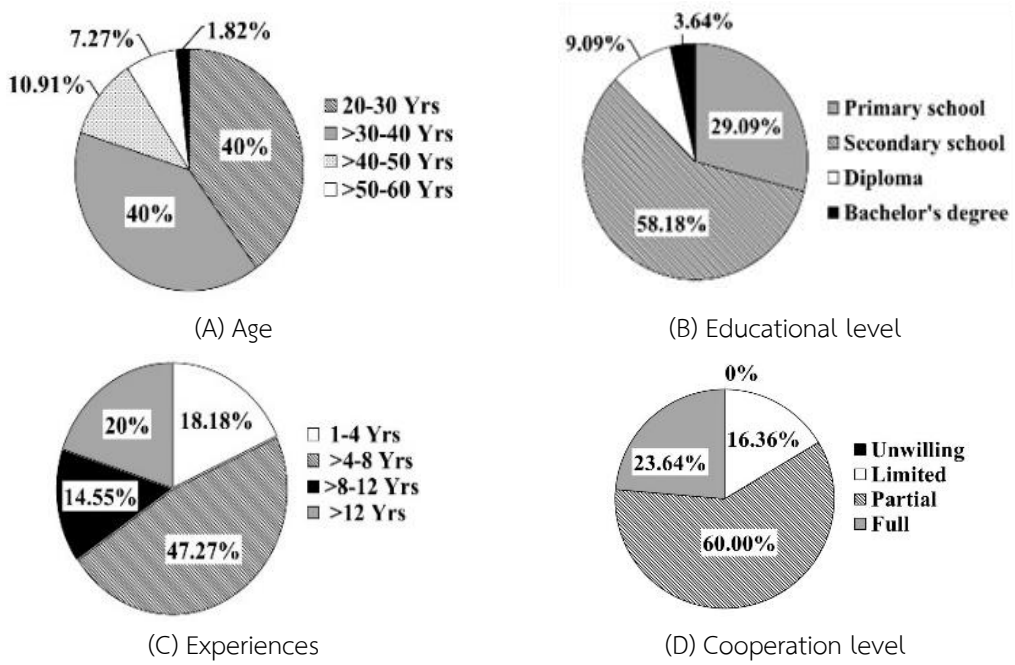

Figure 1 Distribution of respondents by age (A), highest education level obtained (B), farming experience (C), and level of the cooperation with SDC (D).

Most SDC farm size ranged between small-medium (about 60% lactating cows, 16% dry cows, and 24% replacement heifers). All were DLD certified Holstein Friesian crossbreed. An average area of 16,389 m^2 is partitioned for dairy farming and to grow feeds. All maintain similar healthcare protocols. Vaccination program is routinely coordinated as recommended by the DLD. Veterinarians paid routine visits. All respondents reported subclinical mastitis, vector- borne diseases (trypanosomiasis and babesiosis), Foot and Mouth Disease, physical problems from limited grass production, dystocia, and milk fever.

Reproductive and Milk Production Performances (RP and MPP)

The indicators of RP and MPP in this study were summarized on Table 1, revealing favorable RP indices to be CFSC (69.3$\pm$1.30%; 95%CI=68.1, 70.5) and acceptable AFS (21.1$\pm$0.36 months; 95%CI=20.4, 21.8). MPP indices showed effective performance based on moderated DMY (13.4$\pm$0.20 kg/day/cow; 95%CI=13.0, 13.8), which yielded high LMY (3766$\pm$40.1 kg/lactation/cow; 95%CI=3685, 3846). Effectiveness indicator and reference value of each index were discussed in the discussion sections.

Table 1 Reproductive and milk production (RP and MPP) indices of SDC members

Reproductive indices	Mean	Median	SEM	95% CI
AFS (months)	21.1	20.2	0.36	20.4, 21.8
AFC (months)	32.7	32.9	0.39	31.9, 33.4
SPC (times)	2.41	2.38	0.05	2.31, 2.50
CFSC (%)	69.3	67.5	1.30	68.1, 70.5
CCI (days)	436	433	2.39	431, 441
CTC (days)	118	118	1.52	115, 121
Milk production indices				
DMY (kg/day/cow)	13.4	13.2	0.20	13.0, 13.8
LMY (kg/lactation/cow)	3766	3790	40.1	3685, 3846
LL (days)	317	341	3.73	310, 325

SEM = standard error of the mean, CI = confident interval, AFS= age at first service, AFC= age at first calving, SPC= service per conception, CFSC= conception rate at first service after calving, CCI= calving to calving interval, CTC=calving to conception interval, DMY=daily milk yield, LMY=lactation milk yield and LL=lactation length.

The correlation between socio- demographic, farm management, and level of cooperation with RP and MPP.

The age of the respondents had negative correlation to AFC ($r=-0.270$, $p<0.05$) whereas experience had a positively correlation with average DMY ($r=0.386$, $p<0.01$) and LYM ($r=0.391$, $p<0.01$). Farms maintaining their own fodder had positive correlation with CCI ($r=0.279$, $p<0.05$), CCT ($r=0.291$, $p<0.5$) and LL ($r=0.290$, $p<0.05$). Farm size exhibited a positive correlation with AFC ($r=0.296$, $p<0.05$) and CFSC ($r=0.292$, $p<0.05$). The level of cooperation with SDC did not exhibit any correlation with RP index, whereas there was a positive correlation between the level of cooperation and MPP (DYM; $r=0.396$, $p<0.01$; and LMY; $r=0.266$, $p<0.05$) (Table 2).

Table 2 The correlation between socio-demographic, farm management, and level of cooperation with RP and MPP.

Parameters	RP						MPP		
	AFS	AFC	SPC	CFSC	CCI	CCT	DMY	LMY	LL
Farmers' socio-demographic									
Gender	-0.018	0.086	0.154	-0.079	0.005	0.003	-0.129	0.104	-0.034
Age	0.144	-0.270*	-0.247	0.121	0.145	-0.210	-0.123	-0.194	0.046
Educations	-0.193	0.161	0.033	0.035	0.033	0.076	0.066	0.187	0.041
Experiences	-.067	.121	-.127	-.031	-.189	.019	0.386**	0.391**	0.013
Farm-herd management									
Own fodder	-0.019	-0.021	-0.028	0.140	0.279*	0.291*	0.091	0.025	0.290*
Farm size	-0.151	0.296*	0.190	0.292*	0.200	0.185	0.009	0.042	-0.183
Cow culling	0.143	0.066	0.095	0.004	0.214	0.167	0.086	0.066	-0.113
Heifer replacement	0.106	-0.024	0.128	0.214	0.218	-0.062	-0.203	-0.217	0.047
Disease outbreaks	-0.120	-0.082	-0.166	0.209	-0.193	-0.215	0.089	0.128	0.091
AI procedures	0.199	0.012	-0.024	0.184	0.044	0.101	-0.099	-0.066	-0.055
Level of cooperation	-0.140	0.157	-0.164	0.195	0.257	0.062	0.289*	0.385*	0.184

* and ** Correlation is significant at the 0.05 and 0.01 level (2-tailed), respectively. RP=reproductive performance, MPP=milk production performance, AFS=age at first service, AFC=age at first calving, SPC=service per conception, CFSC= conception rate at first service after calving, CCI= calving to calving interval, CTC= calving to conception interval, DMY=daily milk yield, LMY=lactation milk yield and LL=lactation length.

Discussion

Dairy farm RP and MPP are critical indicators to sustainability. These indicators are influenced by internal and external factors, including cow's productivity, farmer's socio-demographic, management, and response to challenges.

AFS is the most significant indicator to forecast cows' preconception health, with the recommended length of 18 months or less. An average AFS of 21.1 months was observed. This length is shorter than previous studies in Thailand (Teepatimakorn et al., 2019, pp. 102-103) and foreign countries (Wangdi et al., 2014; Buaban et al., 2015, pp.4933-4934) and less than 24 months acceptable range, indicating an acceptable fertility achievement in hot and humid regions (Perera, 1999).

Delayed AFC decreases RP, MPP, and lifetime profit. AFC of less than 24 months presents economic advantages with minimal impacts on lactation (Van Amburgh et al., 1998, pp. 535-536). This study exhibited slightly higher AFC than previous report by Elzo et al. (2006, pp. 273-274), reflecting a considerable risk for farmers to focus on replacement-heifers management, diet, and diseases, to maximize fertility and lifespan.

SPC determines effective fertilization management. High SPC indicates postpartum reproductive failure. The observed SPC is higher than the DLD expectation of less than 1.5 times for all farms (Teepatimakorn et al., 2019, pp. 101-103), while still complying with the expected value for smallholder farms (Wangdi et al., 2014; Tancharoen et al., 2016, pp. 16-18), suggesting farmers must focus on the postpartum management to decrease risks of early embryonic loss (Siddiqui et al., 2013, p.500).

CFSC measures the rate of successful fertilization. Positive CFSC depends on the contemporary sequence of obstetric history and the lactation period (Teepatmakorn et al., 2019, p. 99). This study's average CFSC of 69.3% was higher than DLD expectation and previous publications of 29.9-55.0% in Thailand (Aiumlamai, 2009, p. 11; Buaban et al., 2015, p. 4993; Tancharoen et al., 2016, p.15), suggesting progressive reproduction management by SDC members.

CCI and CCT indicate the effectiveness of RP. The expected CCI and CCT is 365 and 95 days, respectively. Cows should conceive around the 85^{th}-90^{th} day of postpartum, with additional days to conception impact economic yield. This study showed an average CCI of 436 days, which was near the previous range reported at 412-420 days in the northeastern Thailand (Buaban et al., 2015, p. 4993). The CCI found was longer than the recommended value while still lower than previous studies in other regions. Tancharoen et al. (2016, p.15) reported CCI in the central-western region at 445-479 days, while Ratanapob et al. (2020, p.767) reported CCI up to 529 days in a herd with laminitis. This study's CTC of 118 days was higher than the expected, yet, still lower than other regions (Ratanapob et al.,2020, p.768). So, regional climate data reported by Kaewlamun et al. (2011, pp.318-320) indicated that cows were exposed to heat stress, signifying high temperatures might influence CCI and CTC (Thammahakin et al., 2020, pp.124-125).

As shown on Table 1, the average DMY in this study was moderate (13.4 kg/day/cow). This finding was consistent with the findings of Pongpiachan et al. (2003, p.1094) in northern Thailand (11.8-12.3 kg/cow/day) and the previous study (8.18-22.5kg/cow/day) in other regions (Wittayakun et al., 2016, p.188). This study's average LMY (3,766 kg/lactation/cow) was higher than the previous reported by Wongpom et al. (2017) but lower than the reports by Seangjun et al. (2009, pp.77-78) and Endris et al. (2012, pp. 546-548). While the average LMY is slightly lower than national expectation (4,000 kg/lactation/cow), MPP was still within an acceptable range and could fulfill the demand. The average LL found was 317 days, which was shorter than previous reports of other regions of 334 to 377 days (Endris et al., 2012, pp.548-549; Tancharoen et al., 2016, pp.14-18). The longer LL further complicated reproductively as the milking process could not be paused within the theoretical standard of 305 days due to the demand for milk productions and the financial stress placed on the farm without any productivity (Vijayakumar et al., 2017, p. 1094). Therefore, the LL from this study was another parameter to suggest excellent management by SDC members.

Unfavorable conditions such as diseases or lack of nutrients could affect performance, but as mentioned, all farmers reported similar health care challenges, but without specifying the severity of individual diseases, thus restricted the statistical determination of the correlation between negative health and performances in this study.

Farmers' age had negative correlation with AFC, while the ability to maintain own fodder at each farm had a positive correlation with CCT, CCI, and LL. The extent of these parameters diminished RP and MPP. Such a decrease raises the risk of not achieving long- term cost effectiveness. The result revealed no correlation between farmer's education level and performance parameters. Even with no correlation between academic knowledge and these parameters, farmers should not disregard the importance of education, which was critical to successful decisions making and management (Odhiambo et al., 2019, pp.595-596).

Farm size had positive correlation with CFSC, indicating systemic management, especially the application of AI technique, estrous management. Nonetheless, farm size exhibited positive correlation to AFC, suggesting the larger number of cows within the farm could influence the inability to properly manage replacement heifer to reach fertility within an appropriate timeframe, potentially brought lesser profit due to decreasing remaining lifespan of to produce more offspring (Kim & Jeong, 2019, pp.522-525).

The factors that positively correlated with satisfactory MPP were farming experience and the level of cooperation with SDC. This may have been due to the benefits provided by the cooperative system to offset the challenges unaffordable by nonmembers, in addition to farming experience certainly provide an advantage to members adapting to challenges.

Conclusions and suggestions

Regardless of the challenges on SDC members, MPP indices (DMY, LMY) were competitive against DLD's expectation and other performances from prior studies, suggesting farmers' experiences and cooperative systems could enhance productivity. Although SDC members achieve a favorable CSFC, improvement could be made with RP, as they underperformed in managing postpartum and replacement heifers to reach optimal fertility age.

With minor shortcomings, the performance by SDC members, especially DMY and LMY, illustrated strong advantages, benefits, and supports enhanced by the cooperative membership, including improved ability to reduce cost, enhanced livestock health care, increased production, and guaranteed sales. These advantages could attract prospects to enter the dairy farm industry using cooperative system. The government, stakeholders, and the industry should support prospective farmers to develop necessary skills and join a cooperative institution to achieve the optimum level of production.

Recommendation for using to benefit

While the SDC members achieved satisfactory MPP, the data suggested mismanagement of postpartum and replacement heifers. Here are the recommendations to improve performance.

1. SDC

1.1 Continuously develop and update the central farm performance and health tracking database, including improving intuitiveness and availability to members.

1.2 Establish training seminar to develop members to introduce innovation within the industry, courses to operate the database, data analysis and synthesis, risk assessments, and management of herd health, nutrition, and reproduction.

2 SDC Members

2.1 Enter the latest performance data into the central database for other members.

2.2 Attend training seminar. Apply the knowledge to improve operation, to include managing proper cow ratio, estrous management, and postpartum diseases.

2.3 Identify other flaws relating to RP, conduct risk assessment and management.

Recommendation for future research

1. Study the factors that enhance the administrative operation of cooperative members, to include human resources, farm administrative structure, cooperative involvement with members.

2. Investigate enhancing factors or risk that hinder farm performances, such as reproductive and nutritional management at the national level, breeds availability, innovative estrous management, AI technique, the quality of semen.

3. Study the long-term economic return of cooperative members such as income and expenditure to investigate the sustainability of cooperative membership.

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