Alexandria Journal of Veterinary Sciences
www.alexjvs.com

AJVS. Vol. 55 (2): 21-27. Oct. 2017
DOI: 10.5455/ajvs.277554

Effect of Herd Size on the Productive, Reproductive, and Economic Efficiency of Holstein Dairy Cows

Abdelgawad S. El-Tahawy
Department of Animal Husbandry and Wealth Development, Faculty of Veterinary Medicine, Damanhur University. Egypt.

Key words:
Holstein cows, Herd size, Economic, Productive, Efficiency

Correspondence to*:

abdelgawad.tahawy@vetmed.dmu.edu.eg

ABSTRACT

A total of 8426 dairy records were randomly selected from 11 dairy herds which had been accepted the request to participate in this study to explore the influence of herd size on the productivity and economic efficiency of the Holstein dairy cows. Records were collected during the period started from 1st January 2016 to 30 January 2017. The localities which the dairy farms were located are El-Beheira, Alexandria and Kafr El-Sheik provinces. All the investigated farms were belonged to the private management system. Herd size was classified into three categories: small (from 100 to 500 cow), medium (501 to 900 cows), and (more than 900). The obtained results showed that total milk yield of the medium size herd (5001-900 cow) was significantly (10080.02±55.51 kg; P<0.05) greater than the herd size for small and large size herd which yielded 8232.79±100.32 kg and 9380.60±58.89 kg, respectively. However, 305-milk yield of large herd size was significantly (8743.95±44.23 kg; P<0.05) greater than the comparable small and medium size herds. In terms of the reproductive performance, small and medium size herds required number of service per conception more than (3.36±0.08 and 3.53±0.06; P<0.05) the large herd size. In terms of the return parameters, total returns and net return of medium size herd were greater than those for small and large size herd.

1. INTRODUCTION

Many factors affecting the productivity and the economic efficiency of dairy farms have been investigated in several past studies. The most important factors in Egypt are breeds, locality, sector, calving season, lactation number and disease incidence (El-Tahawy, 2007). Herd size affected the production efficiency in a study conducted by Simensen et al. (2010) who revealed that in herds with less than 27 cows there were increasingly lower yields in free-stalls, particularly in first parity, whereas the yields were increasingly higher in free-stalls with more than 45 cows.

Jago and Berry (2011) indicated that 305-day milk yield decreased and milk protein and fat percentage increased with increasing rate of expansion (i.e. expansion by average of three or eight cows per year). As well as, they established that there were no associations between herd size and milk production except for protein and fat percentage, which increased with increasing herd size. In the same trend, Kumar et al. (2014) indicated that the milk yield revealed inverse relationship with herd sizes. On the other hand, Atashi et al. (2012) reported that larger herd size was associated with an average increase of 2.69 (±0.35) kg in 305-day milk per 50 cows per herd.

Singh et al. (2016) resulted that the average lactation yield was significantly higher for large herd size farms (5062 litres), whereas, lowest (4232 liters) for small herd size farms, which may be due to the better management practices followed at large dairy farms as compared to small dairy farms.

McDougall (2006) reported that reproductive performance decreased with increased herd size. Besides, Lemma and Kebede (2011) found that, small size farms exhibited the largest days open 217.6 ±102.5 than medium and large sized ones 171.4±68.5 and 161.1±69.6, respectively. However, number of service per conception was higher in large farms (2.9 ±1.8) than medium (2.2 ±1.1) and small ones (2.5 ±1.3). Nevertheless, Jago and Berry (2011) reported that expanding herds and large herds had superior reproductive performance

relative to non-expanding and small herds. In the same line, Atashi et al. (2012) depicted that larger herd size was associated with an average decrease of 0.22 (± 0.02) days in calving interval per 50 cows per herd.

In a study conducted by Sasaki et al. (2016) demonstrated that cows in smaller herds showed low reproductive performance than large ones. Likewise, Singh et al. (2016) found that the herd size had significant effect on days open as the small farms were having the maximum days open 112 days followed by the medium and large farms.

Based on the previous studies, this work aimed to focus on the effect of herd size on the productivity, reproductive, and economic efficiency of the Holstein dairy cows.

2. MATERIALS AND METHODS

2.1. Study population and sampling

A total of 8426 dairy records were randomly selected from 11 dairy herds which had been accepted the request to participate in this study. The breeds which subjected to this study included Holstein breed which is the majority of the collected data. Records were collected during the period started from 1st January 2016 to 30 January 2017. The localities which the dairy farms were located are El-Beheira, Alexandria and Kafr El-Sheik provinces. All the investigated farms were belonged to the private management system.

Herd size was classified according to Singh et al. (2016) into three categories: small (from 100 to 500 cow), medium (501 to 900 cows), and (more than 900).

2.2. Animal management

Cows on the participating farms were housed in the free-stall, shaded open yards with sand floor or concrete floors bedded with straw or sawdust, supplied with a cool spraying system during hot climate. Animals were grouped according to average daily milk yield into fresh (from calving day till 60 days post-partum), high producing cows and low producing cows, all groups of cows were fed a balanced (TMR) but the composition of the diets differed depending on the region and management. Water was freely available all times. The cows were milked in the parlor systems three times daily.

Each milking unit had milk meters capable of automatically recording milk production and milk conductivity. Farm personnel used DairyComp305 herd management software to record lactation, reproductive, and medical data for each cow. The dry period was 60 days prior to calving and, it divided into early dry (far –off) dry period from 60-21 days before calving and late dry (21) days before calving.

Heifers were artificially inseminated for the first time when reaching 380 kg of weight and pregnancy was detected by rectal palpation 60 days after service. Estrus was detected by visually monitoring cows for thirty minutes a.m. and p.m. near predicted estrus. Cows exhibiting estrus after day 60 postpartum were mated via artificial insemination. Insemination occurred approximately 12 hours after a cow was first observed standing for mounting.

2. Variables under investigation

The dependent variables for productive traits were (total milk yield, daily milk yield, and corrected milk yield (305 milk yields)) and economic traits were (labour costs, veterinary services, breeding costs, feed costs, cow depreciation costs, total variable costs and total costs, milk sale, total return, net return, and income over feed costs (IOFC). Collective and partial measures of efficiency were calculated according to El-Tahawy (2007)

The reproductive parameters included days open, calving interval, service per conception and dry period. Total variable costs include the prices of drugs, vaccines, disinfectants, veterinary supervision, breeding costs, feed cost, labour cost and other miscellaneous costs have been spent on other facilities such as water and electricity etc, according to (Jayaweera et al., 2007). All the calculated costs based on the prevailing prices during the period of the study and were calculated on the basis of Egyptian pound (EGP). Total costs included total feed costs, labour costs, the miscellaneous costs, the costs for veterinary services and breeding operations, depreciation of fixed assets, cow depreciation costs according to, (Krpalkova et al., 2016).

Income over feed costs (IOFC) which used to measure income without fixed and labour costs. It shows the present profitability of the animal having a dry date or the cow entered the herd and calculated according to (Jagannatha et al., 1998) by multiplying milk yield per cow by current milk price minus total feed cost per cow).

2.4. Statistical analyses

The data were analyzed using one-way analysis of variance using SPSS version 21. Duncan's multiple

range test was used to determine the significant differences among means of analysed parameters which related to productive, reproductive, and economic parameters of dairy production (Armitage et al., 2008) and significance was declared when P<0.05.

3. RESULTS AND DISCUSSION

Data showed in Table 1 declared that total milk yield of the medium size herd (5001-900 cow) was significantly (10080.02±55.51 kg; P<0.05) greater than the herd size for small and large size herd which yielded 8232.79±100.32 kg and 9380.60±58.89 kg, respectively. However, 305-milk yield of large herd size was significantly (8743.95±44.23 kg; P<0.05) greater than the comparable small and medium size herds. Days in milk for the small herd were significantly longer than those for medium and large herd size. Our results are supported by the studied conducted Smith el al. (2000) who revealed that the milk production levels vary among different herd sizes of cattle and the medium and large size herd producing more milk yield than the small herd size. Moreover, the findings obtained by Jago and Berry (2011) indicated that 305-day milk yield decreased and milk protein and fat percentage increased with increasing rate of expansion (i.e. expansion by average of three or eight cows per year). On the other hand, Kumar et al. (2014) indicated that the milk yield revealed inverse relationship with herd sizes. Correspondingly in recent study conducted by Horvath and Miko (2016), they concluded that there was a strong positive correlation between the herd size and milk production (r=0.72; R 2 =0.512).

The reproductive parameters represented by service per conception and calving interval and days open were obtainable in Table 2. Days open of the large herd size was longer (158.072.36 days) than the days open of small and medium size herds. Small and medium size herds required number of service per conception more than (3.36±0.08 and 3.53±0.06; P<0.05) the large herd size. Dry period of the medium size herd was shortest when compared with the small and large herd size. These results are in agreement with McDougall (2006) who reported that reproductive performance decreased with increased herd size. Besides, Lemma and Kebede (2011) found that, small size farms exhibited the largest days open 217.6 ±102.5 than medium and large sized ones 171.4±68.5 and 161.1±69.6, respectively. Nevertheless, Jago and Berry (2011) reported that expanding herds and large herds had superior reproductive performance relative to non-expanding and small herds. Singh et al. (2016) found that the herd size had significant effect on days open as the small farms were having the maximum days open 112 days followed by the medium and large farms.

In regard to the veterinary management costs calculated, veterinary supervision, drug, disinfectant, and vaccine values for medium size herd were significantly greater than the small and large herd size as depicted in Table 3. In total, total veterinary management costs for medium size herd were significantly greater (743.91±3.46 EGP) than those for large and small size herd.

Regarding the service costs and other costs incurred (Table 4), cows in medium size herd costed greater service cost than the service costs for small and large herd size (423.13±6.68 EGP vs. 238.65±7.09 and 217.96±3.34 EGP; P<0.05). Moreover, total feed costs for cows in medium size herd (26343.60±134.66 EGP) were greater than total feed costs for small (21075.68±240.87 EGP) and large size herd (24292.29±136.91 EGP). The same trend was observed for the total variable costs for the medium size herd compared with the small and large size herd. Ramsey et al. (2005) showed that herd size was significantly (P<0.01) affected cost of bedding material. Where, small herd size had higher bedding cost per animal than large sized herds. Furthermore, von Keyserlingk et al. (2013) point out those large herds had higher production and lower unit costs of milk and this could attribute to spreading fixed costs across more production. Singh et al. (2016) reported that feed cost varies significantly among different herd sizes, as the feed cost at large farms was higher than that of medium and small farms because they had selected animals with high production potential; hence required more quality feed. Additionally, they found that herd size has non-significant effect on income over feed ratio.

The fixed costs were presented in Table 5. The total costs for cows in medium size herd were greater (29760.50±144.1 EGP) when compared with small and large size herd. In terms of the return parameters (Table 6), total returns and net return of medium size herd were greater than those for small and large size herd. Kumar et al. (2014) reported that net profit of milk production of a cross-bred cow per day was the highest on small herd size group (Rs. 19.49) followed by medium (C.18.62) and large size group (C.18.01) in Karnal district. Additionally, Dong et al. (2016) showed that larger size herds can continue in the production process than smaller size herds. As well, the profitability measures for larger size herds were superior to the comparable small size herds.

Table 1: Effect of herd size on the productive parameters of the Holstein-dairy cows.

Item	TMY	DMY	305 yield	DIM
Herd size:				
Small (100-500)	8232.79±100.32^{c}	22.84±0.24^{c}	6965.1±74.19^{c}	370.40±3.60^{a}
Medium (501-900)	10080.02±55.51^{a}	28.15±0.11^{a}	8585.35±32.2^{b}	360.78±1.79^{b}
Large (>900)	9380.60±58.89^{b}	26.29±0.14^{b}	8743.95±44.23^{a}	363.37±2.06^{b}

TMY= total milk yield. DMY= daily milk yield. DIM= days in milk
Means within the same column carrying different letters are significantly different (P<0.05)

Table 2: Effect of herd size on the reproductive parameters of the Holstein-dairy cows.

Level	DO	SC	CI	DP
Herd Size**:**				
Small	138.173.94^{b}	3.36±0.08^{a}	418.17±3.94^{b}	77.9±1.55^{a}
Medium	142.931.84^{b}	3.53±0.06^{a}	422.93±1.84^{b}	62.15±0.39^{b}
Large	158.072.36^{a}	2.91±0.04^{b}	438.07±2.36^{a}	74.7±1.28^{a}

DO= days open. SC= service per conception. CI= calving interval. DP= dry period
Means within the same column carrying different letters are significantly different (P<0.05)

Table 3: effect of herd size on the veterinary management cots for the Holstein dairy farms

Item	Labor cost	Veterinary supervision	Disinfectant cost	Vaccine cost	Drug cost	TVM
Herd size:						
Small	1019.12±13.14^{a}	186.50±1.60^{a}	84.08±1.42^{b}	89.60±1.47^{c}	279.02±3.92^{c}	639.21±7.60^{b}
Medium	624.30±2.68^{b}	186.83±0.92^{a}	103.25±0.47^{a}	114.49±0.51^{a}	339.34±1.56^{a}	743.91±3.46^{a}
Large	569.83±3.070^{c}	93.93±0.51^{b}	60.01±0.32^{c}	96.02±0.52^{b}	300.05±1.62^{b}	550.00±2.97^{c}

TVM= total veterinary management costs
Means within the same column carrying different letters are significantly different (P<0.05)

Table 4: Variable costs for the cows in different herd size.

Level	Service cost	miscellaneous cost	lactating feed cost	dry feed cost	Total feed cost	TVC
Herd size:						
Small	238.65±7.09^{b}	185.82±1.68^{b}	18959.02±223.58^{c}	2116.66±50.7^{b}	21075.68±240.87^{c}	23158.48±257.35^{c}
Medium	423.13±6.68^{a}	196.98±0.86^{a}	24866.34±135.87^{a}	1477.26±11.21^{c}	26343.60±134.66^{a}	28331.92±144.24^{a}
Large	217.96±3.34^{c}	198.03±1.07^{a}	20930.76±132.57^{b}	3361.53±57.39^{a}	24292.29±136.91^{b}	25828.11±142.65^{b}

TVC: Total variable costs
Means within the same column carrying different letters are significantly different (P<0.05)

Table 5: Fixed costs for the dairy cows in different herd size

Item	Building depreciation	Parlor depreciation	Animal price	Animal depreciation	TFC	TC
Herd size:						
Small	352.62±3.76[a]	297.97±3.49[a]	22473.46±31.38[c]	960.50±4.48[c]	1611.09±6.77[a]	24769.57±256.45[c]
Medium	184.42±0.10[b]	178.45±0.13[b]	23210.01±8.39[b]	1065.71±1.2[a]	1428.59±1.17[c]	29760.50±144.1[a]
Large	143.48±0[c]	101.45±0[c]	25000.00±0[a]	1321.43±0[b]	1566.36±0[b]	27394.47±142.65[b]

Means within the same column carrying different letters are significantly different (P<0.05)

Table 6: Return parameters for the dairy cows in different herd size

Item	**Manure sale**	**Calf sale**	**Milk sale**	**Total return**	**Net return**
Herd size:					
Small	210.07±0.99[b]	4333.95±23.64[b]	32620.98±414.67[c]	37164.99±418.17b	12395.42±241.74[c]
Medium	223.06±0.12[a]	4605.01±4.20[a]	42840.07±235.92[a]	47668.13±234.56[a]	17907.63±132.46[a]
Large	199.65±0[c]	4250.00±0[c]	38929.50±244.37[b]	43379.15±244.37[b]	15984.68±163.54[b]

Means within the same column carrying different letters are significantly different (P<0.05)

Table 7: Collective efficiency measures for the different herd size

Level	**TR/TC**	**TR/TVC**	**Net profit/TVC**	**Net profit /TC**
Herd size:				
Small	151.08±0.93[b]	162.64±1.03[b]	55.04±1.01[b]	51.08±0.93[b]
Medium	161.07±0.41[a]	169.69±0.44[a]	64.35±0.44[a]	61.07±0.41[a]
Large	159.55±0.55[a]	169.88±0.59[a]	63.45±0.58[a]	59.55±0.55[a]

Means within the same column carrying different letters are significantly different (P<0.05)

Table 8: Partial efficiency measures for the different herd size.

Item	**TVM/TVC %**	**TVM/TC %**	**drug/TMY (EGP)**	**Vaccine/TMY (EGP)**	**Disinf/TMY (EGP)**	**Vet sup/TVM(EGP)**	**TVM/TMY(EGP)**
Herd size:							
Small	2.82+0.022[a]	2.62+0.02[a]	0.035+0[a]	0.011+0[b]	0.010+0[b]	0.025+0[a]	0.081+0[a]
Medium	2.68+0.01[b]	2.54+0.009[b]	0.035+0[a]	0.012+0[a]	0.011+0[a]	0.019+0[b]	0.076+0[b]
Large	2.17+0.008[c]	2.04+0.008[c]	0.034+0[b]	0.011+0[b]	0.007+0[c]	0.011+0[c]	0.062+0[c]

Means within the same column carrying different letters are significantly different (P<0.05)

Table 9: Cost of kilogram of milk from the veterinary management costs in different herd size (Piaster)

Item	**drug/TMY**	**Vaccine/TMY**	**Disinfectant/TMY**	**Veterinary supervision/TMY**	**TVM/TMY**
Herd size:					
Small	3.47±0.038[a]	1.10±0.013[b]	1.04±0.014[b]	2.47±0.033[a]	8.08±0.085[a]
Medium	3.48±0.016[a]	1.18±0.005[a]	1.10±0.005[a]	1.91±0.009[b]	7.63±0.035[b]
Large	3.39±0.024[b]	1.08±0.008[b]	0.68±0.005[c]	1.06±0.007[c]	6.21±0.043[c]

Means within the same column carrying different letters are significantly different (P<0.05)

Table 10: Ratio of the cost of one kilogram of milk to its price and the milk income over feed cost

Level	kg milk to total cost (EGP)	kg price to its cost (EGP)	kg price (EGP)	MIFC milk income to feed cost (EGP)
Herd size:				
Small	3.11±0.02[a]	1.31±0.009[b]	3.95±0.007[c]	11545.30±242.78[c]
Medium	3.01±0.01[b]	1.44±0.004[a]	4.25±0.001[a]	16496.46±138.98[a]
Large	3.02±0.01[b]	1.42±0.005[a]	4.15±0.002[b]	14637.21±163.90[b]

Means within the same column carrying different letters are significantly different (P<0.05)

Collective and partial measures were calculated and presented in Tables 7 and 8. the percentage of net return to total variable and total costs were significantly greater medium and large size herds when compared with the small size herd. Additionally, the partial measures of veterinary management were also considered. The ratio of total veterinary management to the total milk yield (Table 9) was significantly greater (8.08 piaster) for small herd size when compared with medium and large herd size. Moreover, the cost of one kilogram of milk is greater in small size herd (3.11 piaster). Moreover, the kilogram of milk in relation to its cost was significantly greater in medium (1.44 piaster) and large herd (1.41 piaster) than the small herd size (1.31 piaster). On the other hand, the milk income over feed costs (Table 10) was significantly higher in medium size herd (16496.46±138.98 EGP) than those for large and small size herd. Bailey et al. (1997) showed that total feed cost and income over feed cost (IOFC) were greater in lager herds than smaller ones. Correspondingly, Oleggini et al. (2001) indicated higher income in relation to the feed cost (IOFC) was calculated for larger herds compared to the small one and this could be attributed to improved reproduction (decreased days open) and increased percentage of cows in milk

4. CONCLUSION

This study concluded that medium size herd had superiority regarding the productivity and reproductive and return parameters than the small and large size herd.

5. ACKNOWLEDGMENT

The author would like to introduce his grateful to the farmers and veterinary doctors supervising the investigated farms for their kind help during data collection.

6. REFERENCES

Atashi, H., Zamiri, M., Sayyadnejadm M.S., Akhlaghi, A., 2012. Trends in the reproductive performance of Holstein dairy cows in Iran. Trop. Anim. Health. Prod. 44:2001–2006.

Dong, F., Hennessy, D., Jensen, H., Volpe, R., 2016. Technical efficiency, herd size, and exit intentions in U.S. dairy farms. Agric. econ. 47: 1-13.

El-Tahawy, A.S. 2007. Cattle diseases and their effects on economic and productive efficiency of dairy farms. Ph. D. Faculty of Veterinary Medicine, Alexandria University.

Horváth, J., mikó, E. 2016. Impact of economic environment on herd size and milk production on a dairy cattle farm. Lucrări ştiinţifice, seria i, vol.xviii (1).

Jagannatha, S., Keown, J., Van Vlek, L.D., 1998. Estimation of Relative Economic Value for Herd Life of Dairy Cattle from Profile Equations. J. Dairy. Sci. 81(6):1702-8.

Jago, J. G., Berry, D. P. 2011. Associations between herd size, rate of expansion and production, breeding policy and reproduction in spring-calving dairy herds. Anim. 5(10):1626–1633.

Krpalkova, L., Cabrera, V., Kvapilik, J., Burdych, J., 2016. Associations of reproduction and health with the performance and profit of dairy cows. Agric. Econ. – Czech. 62 (8): 385–394

Kumar, N., Suhag, K.S., Bishnoi, P., Kumar, S., Chaudhary, K.R., 2014. Economic analysis of cross-bred cow milk production vis-à-vis economic traits in haryana. Ind. J. Anim. Res. 48 (3): 270-275.

Lemma, A., Kebede, S. 2011. The effect of mating system and herd size on reproductive performance of dairy cows in market oriented urban dairy farms in and around Addis Ababa. Revue. de Médecine. Vétérinaire. 11: 526-530.

McDougall, S. 2006. Reproductive performance and management of dairy cattle. J. Reprod. Develop. 52 (1), 185-194.

Oleggini, G.H., Ely, L.O., Smith, J.W., 2001. Effect of Region and Herd Size on Dairy Herd Performance Parameters. J. Dairy. Sci. 84 (5): 1044-1050.

Sasaki, Y., Uematsu, M., Kitahara, G., Osawa, T., 2016. Reproductive performance of Japanese Black cattle: Association with herd size, season, and parity in commercial cow-calf operations. Theriogenology. 86 (9): 2156–2161

Simensen, E., Østerås, O., Egil Bøe, K., Kielland, C., Ruud, L., Næss, G., 2010. Housing system and herd size interactions in Norwegian dairy herds; associations with performance and disease incidence. Acta. Veterinaria. Scandinavica. 52:14.

Singh, P., Bhatti, J.S., Hundal, J.S., Kansal, S.K., 2016. Effect of Region and Herd Size on Dairy Herd Performance Parameters in Punjab. Ind. J. Ecol. 43 (1): 373-374.

Ramsey, R., Doye, D., Ward, C., McGrann, J., Falconer, L., Bevers, S., 2005. Factors affecting beef cow-herd costs, production, and benefits. Journal of Agric. Applied. Econ. 37(01).

von Keyserlingk, M.A., Martin, E. Kebreab, Knowlton, K.F., Grant, R.J., 2013. Invited review: sustainability of the US dairy industry. . Publications from USDA-ARS / UNL Faculty. 1174.