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Research Article

A Meta–analysis of the Impact of Parity on Dystocia and Stillbirth in Holstein Cattle

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ABSTRACT

Dystocia and stillbirth are major factors reducing the productivity of dairy cattle. The objective of this study was to determine the effect of parity on the rates of dystocia and stillbirth. A meta–analysis was conducted to investigate the impact of first parity (primiparous) and later parities (multiparous) on dystocia and stillbirth in Holstein cattle. A total of 30 and 19 papers were analyzed for evaluation of two traits. Results revealed that primiparous cattle are more susceptible to dystocia [Odds Ratio (OR) = 2.68, 95% Confidence interval (CI) 2.51 to 2.85], stillbirth (OR = 2.18, 95% CI 1.84 to 2.58) as compared with multiparous. These results supported the opinion about the importance of considering primiparous and multiparous as different traits in genetic evaluation and shed light on the importance of improving genetics and environment of heifers to minimize the effect of dystocia and stillbirth in Holstein cattle.

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INTRODUCTION

Meta–analyses can be defined as systematic reviews with pooled data (Ton et al., 2007). It was considered as a valuable method with unique properties: establishing whether scientific findings are consistent (Cook et al., 1998) and can be generalized across populations (Burrin and Britton, 1986), limit bias, improve reliability and accuracy of conclusions (Collett, 1994) and increase the power and precision of treatment effects (Bell and Bauman, 1997).

In recent years, breeders have shown increasing interest in selection of functional traits in dairy cattle (Mark, 2004), therefore they have focused to shift selection from traits that increasing–profit to reducing–costs traits (De Maturana, 2007). Health management has been emphasis in order to minimize losses due health disorders (Beaudea et al., 2000).

Dystocia and stillbirth are related terms; as dystocia associated with approximately 50% of calf mortality cases at birth (Mee, 2008). These two traits may result in direct losses due to calf and, dam mortality and premature culling, as well as indirect costs due to additional veterinary services, labor and treatment (Szucs et al., 2009).

Dystocia and stillbirth are generally scored on categorical or binary scales which make them sensitive to subjectivity (Dekkers, 1994).

Dystocia may be defined as delayed or difficult parturition. It's an important problem in Holstein cattle since one birth of every 5 to first parity dams need assistance (Philipsson, 1996). Stillbirths are defined as a calf that dies just before, during, or within the first 24 to 48 h after birth with at least 260 days of gestation (Meyer et al., 2001; Chassagne et al., 1999).

Several studies revealed that primiparous and multiparous cows clearly differ in the rate of dystocia and stillbirths. Meyer et al., (2001) confirmed that statistical analysis of the two traits could be best when considering primiparous and multiparous cows as separated traits.

The aim of this study is to view an extract of estimations (Odds ratio) for the effect of primiparous and multiparous on dystocia and stillbirth in Holstein cattle.

MATERIALS AND METHODS

Extensive literature search of scientific electronic search engines (PubMed, Google Scholar, CAB, ISI Web of Knowledge, Science Direct, SciQuest, and Scirus) was conducted to identify primary studies carried out between 1980 and 2013. Following rigorous screening for appropriate subject matter, high quality of studies, and adequate statistical reporting, were extracted for meta–analysis. Several keyword combinations (dystocia, stillbirth, odds ratio, calving problems, Holstein cattle, meta–analysis) were used. Criteria examined included randomization of study, recording, statistical analysis. Analytic techniques described by Dohoo et al., (2003).

Articles were selected to meet the following criteria:

(1) published in English
(2) published as peer reviewed original articles
(3) must had information about dystocia and stillbirth in first and later parity
(4) articles of Holstein cows only were included in the analysis
(5) The non–peer–reviewed studies were assessed and included in the meta–analysis if they met the selection criteria.

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The articles selected were generally American or European as shown in Table 2 and 3.

Thirty papers were used to evaluate the impact of primiparous and multiparous cows on dystocia and nineteen papers for stillbirth. The scoring of dystocia was not constant in all papers, whereas stillbirth was recorded as dichotomous. The definition of dystocia was not standardized across studies (Table 1). Most studies classified dystocia within 5 categories including unassisted, easy, moderate, difficult, and very difficult. Some studies were recorded dystocia with four categories: = easy (non–assisted), 2 = moderate assistance (veterinarian called as precaution), 3 = difficult, 4 = very difficult with veterinary assistance. Some else recorded dystocia with three categories: no assist, easy and hard or two categories: unassisted and assisted.

Table 1: Classification of dystocia studies according to scores of dystocia

Study name	No. of category	Study name	No. of category
Cady and Burnside (1982)	3	Ansari-Lari (2007)	4
Martinez et al., (1983)	5	Lombard et al., (2007)	4
Djemali et al., (1987) A	5	de Maturana et al., (2007)	5
Djemali et al., (1987) B	5	Gonzalez–Recio et al., (2007)	4
Weller et al., (1988)	2	Lopez et al., (2007)	5
Lin et al., (1989)	2	Wall et al., (2008)	5
Berger (1994)	5	Wiggans et al., (2008)	5
Dematawewa and Berger (1997)	5	Fiedlerova et al., (2008)	3
Meyer et al., (2001)	5	Olson et al., (2009)	5
Johanson and Berger(2003)	5	Van Plet et al., (2009)	6
Steinbock et al.,(2003)	2	Gevrekci et al., (2011)	4
van Tassell et al.,(2003)	5	Hébert et al., (2011)	4
Adamec et al.,(2006)	5	Eaglen et al., (2012)	4
Heins et al., (2006)	5	Atashi et al., (2012a)	5
Steinbock (2006)	2	Dhakal et al., (2013)	5

Table 2: A summary of dystocia studies

Study name	Primiparous Events	Primiparous Total–N	Multiparous Events	Multiparous Total–N	Country
Cady and Burnside (1982)	1851	7845	1833	21661	Canada
Martinez et al., (1983)	8033	29130	10964	107645	USA
Djemali et al., (1987) A	20979	83919	38756	387565	USA
Djemali et al., (1987) B	2126	11189	7828	130466	USA
Weller et al., (1988)	8594	106751	4292	146973	Israel
Lin et al., (1989)	292	1722	240	3186	USA
Berger (1994)	15298	907915	9347	2732741	USA
Dematawewa and Berger (1997)	13628	71618	3490	51096	USA
Meyer et al.,(2001)	31820	167472	29932	498869	USA
Johanson and Berger (2003)	586	1558	325	2775	USA
Steinbock et al., (2003)	34146	411409	12653	281193	Sweden
van Tassell et al., (2003)	588838	2612288	756380	7582809	USA
Admec et al., (2006)	9982	47615	12504	170568	USA
Heins et al., (2006)	61	371	26	303	USA
Steinbock (2006)	28954	804268	16829	673150	Sweden
Ansari-Lari (2007)	147	815	135	1861	Iran
Lombard et al., (2007)	486	2574	359	5214	USA
de la Calle (2007)	1008	29567	419	22660	Spain
Gonzalez–Rico et al., (2007)	3212	62134	1717	71547	Spain
Lopez et al., (2007)	887	25810	482	27543	Spain
Wall et al., (2008)	7117	37261	2343	23265	UK
Wiggans et al., (2008)	647529	4035953	766362	11101267	USA
Fiedlerova et al., (2008)	14047	158192	10364	251063	Czech
Olson et al., (2009)	31	86	18	155	USA
Van Plet et al.,(2009)	4813	42968	3746	114913	Netherlands
Gevrekci et al.,(2011)	833	4495	1169	14944	Turkey
Hébert et al., (2011)	1801	138538	2087	279845	Canada
Eaglen et al.,(2012)	8680	30640	9241	54744	UK
Atashi et al.,(2012a)	6265	63041	1987	37587	Iran
Dhakal et al.,(2013)	11	51	10	139	USA

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Table 3: A summary of stillbirth studies

Study name	Primiparous Events	Primiparous Total-N	Multiparous Events	Multiparous Total-N	Country
Weller et al., (1988)	8177	106751	5600	146973	Israel
Harber (1992)	119489	1048145	147075	2779295	Netherlands
Meyer et al., (2001)	18417	167472	28242	498869	USA
Johanson and Berger(2003)	195	1558	127	2775	USA
Steinbock et al., (2003)	29210	411409	7592	281193	Sweden
Bar (2005)	437	6570	406	11178	Israel
Adamec et al.,(2006)	3399	28862	2841	45915	USA
Heins et al., (2006)	56	371	37	303	USA
Steinbock (2006)	32171	804268	12790	673150	Sweden
Bicahlo et al.,(2007)	566	5288	330	8320	USA
Lombard et al., (2007)	324	2574	318	5214	USA
Cole et al., (2007)	108897	1773099	258957	5247452	USA
Wall et al., (2008)	4583	37261	1402	23265	UK
Wiggans et al., (2008)	223792	1965653	251176	5375384	USA
Olson et al., (2009)	18	86	8	157	USA
Atashi (2011)	415	5205	318	7078	Iran
Atashi et al., (2012b)	6805	126017	4500	179040	Iran
Eaglen et al.,(2012)	3354	30640	2354	54744	UK
Dhakal et al.,(2013)	8	51	18	139	USA

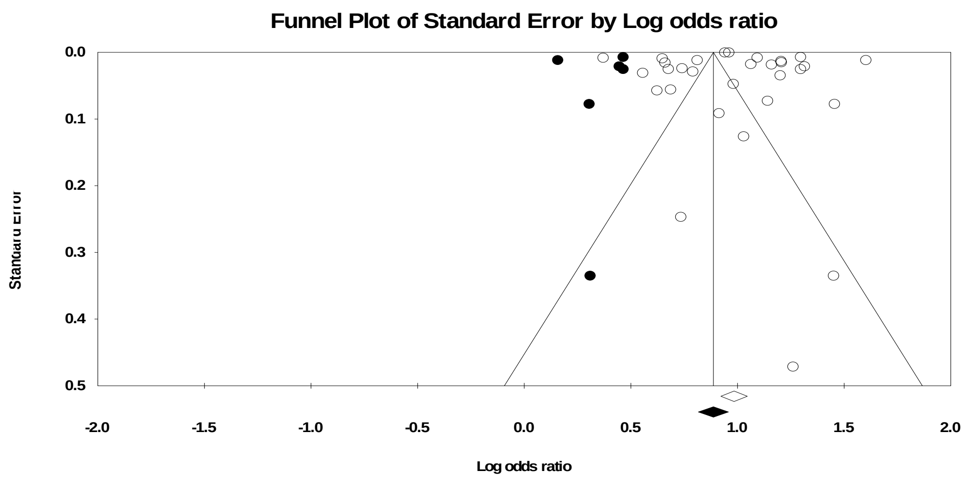

Figure 1: A funnel plot for detection bias of OR in dystocia

Meta-analyses were conducted on dystocia and stillbirth using Comprehensive Meta-Analysis.V.2 software (2013), whereas forest plot was carried out by using MedCalc V.6 (2013). Guidelines for conducting appropriate meta-analysis were largely based on meta-

Data Analysis

Analysis of Potential Publication Bias

A funnel plot: two modes were available, one which plots a study's effect size against its standard error and another which plots effect size against precision.

In the absence of bias the plot would be symmetric about the summary effect (Duval andTweedie2000):

Test the rank correlation (Kendall's tau) between the standardized effect size and the variances (or standard errors) of these effects (Begg and Mazumdar, 1994).

Test the standardized effect (the regression of effect size divided by standard error on precision (inverse of standard error).

Analysis of Heterogeneity

Heterogeneity of the estimated OR was assessed using the Cochran's Q statistic chi square test (Egger et al., 2001). If there was evidence of heterogeneity, then a random model (inverse variance) is preferred. The degree of heterogeneity was assessed by the I^2 (I squared) statistic. This describes the percentage of the variability in effect estimates that is due to heterogeneity rather than sampling error (chance) (Higgins et al., 2003).

RESULTS AND DISCUSSION

Effect of Primiparous and Multiparous on Dystocia

Results shows that I^2 = 99.72, and P = 0.000. An I^2 value >50 may be considered indicative of substantial heterogeneity. In such case a random model is considered more suitable than fixed model (Rabiee et al., 2012). Estimated OR with a random model for dystocia is OR = 2.68, 95% CI 2.51 to 2.85 and the corresponding estimates in a fixed model is OR = 2.61, 95% CI 2.60 to 2.61 (Table 4).

It's obvious from Figure (1) the presence of bias as the OR values were distributed asymmetrically. Pooled OR was

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Table 4: Odds ratio of dystocia for different studies

Study name	Odds ratio	Lower limit	Upper limit	Z-Value	P	Weight (Fixed)	Weight (Random)
Cady and Burnside (1982)	3.340	3.112	3.585	33.412	0.00	0.12	3.67
Martinez et al., (1983)	3.358	3.251	3.468	73.248	0.00	0.55	3.81
Djemali et al., (1987) A	3.000	2.944	3.057	114.395	0.00	1.63	3.84
Djemali et al., (1987) B	3.675	3.487	3.873	48.621	0.00	0.21	3.75
Weller et al., (1988)	2.911	2.803	3.022	55.802	0.00	0.41	3.80
Lin et al., (1989)	2.507	2.089	3.007	9.891	0.00	0.02	2.89
Berger (1994)	4.994	4.866	5.124	121.969	0.00	0.87	3.83
Dematawewa and Berger (1997)	3.206	3.083	3.333	58.380	0.00	0.38	3.79
Meyer et al.,(2001)	3.675	3.613	3.738	150.955	0.00	2.03	3.84
Johanson and Berger (2003)	4.545	3.894	5.305	19.196	0.00	0.02	3.11
Steinbock et al., (2003)	1.921	1.881	1.962	60.956	0.00	1.31	3.83
van Tassell et al., (2003)	2.626	2.617	2.636	504.658	0.00	41.13	3.85
Admec et al., (2006)	3.353	3.258	3.450	82.887	0.00	0.71	3.82
Heins et al., (2006)	2.096	1.288	3.411	2.980	0.003	0.00	1.14
Steinbock (2006)	1.456	1.429	1.485	38.221	0.00	1.56	3.84
Ansari-Lari (2007)	2.814	2.191	3.613	8.106	0.00	0.01	2.37
Lombard et al., (2007)	3.148	2.721	3.642	15.423	0.00	0.03	3.18
de la Calle (2007)	1.874	1.670	2.102	10.675	0.00	0.04	3.40
Gonzalez-Rico et al., (2007)	2.217	2.089	2.353	26.177	0.00	0.16	3.72
Lopez et al., (2007)	1.998	1.786	2.235	12.088	0.00	0.05	3.42
Wall et al., (2008)	2.108	2.006	2.216	29.294	0.00	0.23	3.76
Wiggans et al., (2008)	2.577	2.568	2.586	525.841	0.00	46.46	3.85
Fiedlerova et al., (2008)	2.263	2.205	2.323	61.090	0.00	0.84	3.83
Olson et al., (2009)	4.290	2.218	8.298	4.326	0.00	0.00	0.72
Van Plet et al.,(2009)	3.743	3.581	3.913	58.455	0.00	0.30	3.78
Gevrekci et al.,(2011)	2.680	2.435	2.951	20.120	0.00	0.06	3.53
Hébert et al., (2011)	1.753	1.645	1.868	17.361	0.00	0.14	3.70
Eaglen et al.,(2012)	1.946	1.882	2.012	39.042	0.00	0.52	3.81
Atashi et al.,(2012a)	1.977	1.877	2.083	25.605	0.00	0.21	3.75
Dhakal et al.,(2013)	3.548	1.404	8.964	2.677	0.007	0.00	0.39
Fixed	2.610	2.604	2.617	781.897			
Random	2.680	2.518	2.851	31.157			

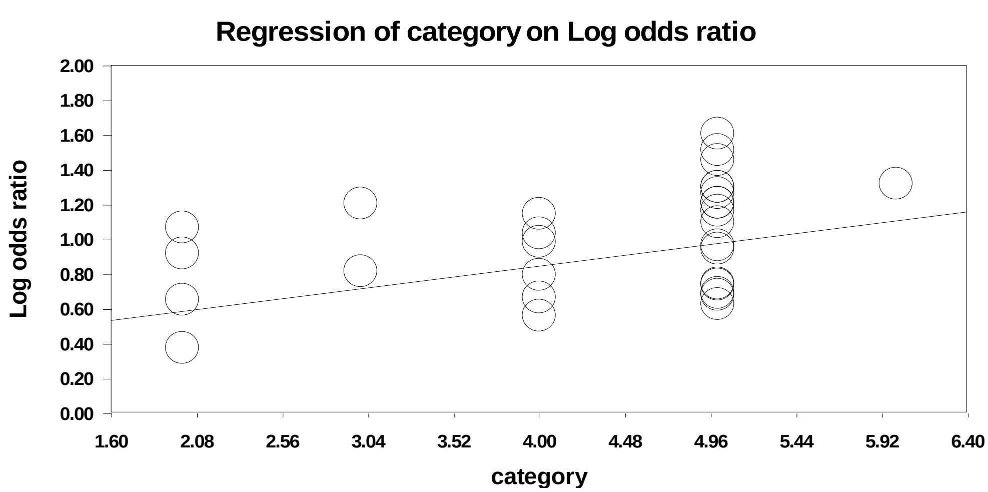

Figure 2: Illustrate the heterogeneity as a regression of dystocia categories (classification according to scores of dystocia) on logarithms of OR by using fixed effect regression

corrected according to fill and trim method "Durval and Tweedie".

Sex studies accounting for gender were needed in dystocia to be symmetrically distributed. The observed OR value of random effect was 2.68, 95% CI (2.51, 2.85), Q value

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10615.92 whereas the adjusted OR was 2.42, 95% CI (2.26, 2.60), 13133.952.

Egger's linear regression method, quantifies the bias captured by the funnel plot. Egger's method uses the actual values of the effect sizes and their precision. The rank correlation test of Begg and Mazumdar (1994) showed that there was no significant correlation between effect and study size (P = 0.39). This was also confirmed by the regression test of Egger et al. (1997), which showed no significant association between study size and effect (intercept = 1.45, P = 0.36).

Heterogeneity in studies could be belonging to many reasons such as: studies conducted by different people, in different areas, with different definitions and at different times, which create a heterogeneous population of studies. Differences between studies in terms of the definition or measurement of outcomes, may lead to differences in observed effects (Lean et al., 2009). As I^2 (I square) was significant (99.72), hence the sources of heterogeneity of response were investigated by meta-regression.

In our research, heterogeneity could be attributed to differences in definition of dystocia (categories). To investigate the validity of using this factor as predictor factor, data were analyzed using ANOVA. T-test was confirmed the significant ($P < 0.05$) differences between OR estimates. Hence, data were subjected to meta-regression. Two types of regression were used: fixed effect regression which shows that the slope is 0.13, 95%CI (0.12, 0.13), P = 0.000 with intercept 0.32, 95%CI (0.30, 0.34), P = 0.000 (Figure 2) and mixed effect regression which shows that the slope is 0.11, 95%CI (0.02, 0.20), P = 0.000 with intercept 0.52, 95%CI (0.12, 0.91), P = 0.000 (Figure 3). The significant effects of two regressions confirmed the effect of dystocia categories on the value of log OR. It was shown from the two Figures (2, 3) that the OR increased as category increasing.

Figure (4) illustrate each study represented by a circle proportional to its weight in the analysis. This view identifies which studies have the greatest impact on the slope of the regression line. Studies with five categories have more impact on slope.

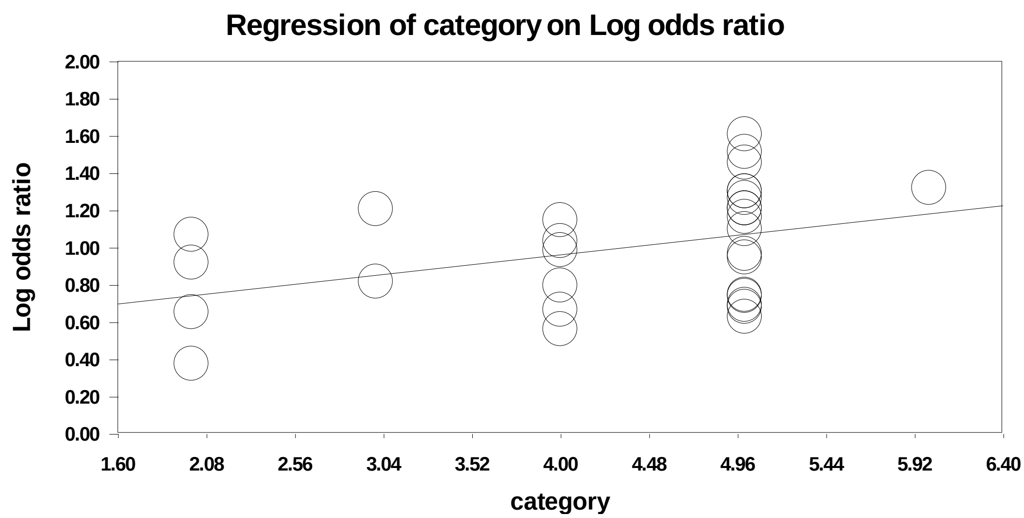

Figure 3: Illustrate that the heterogeneity attributed to dystocia categories by using mixed effect regression (unrestricted maximum likelihood)

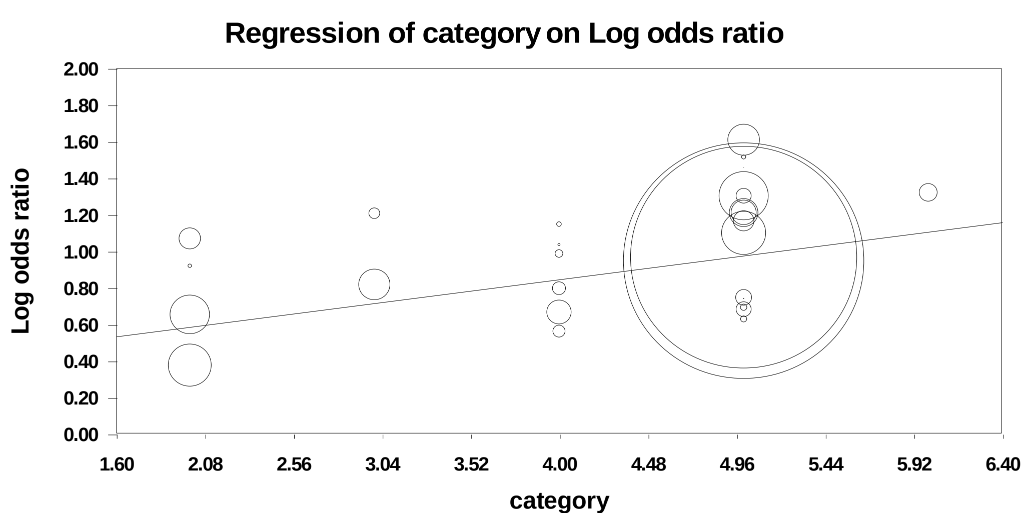

Figure 4: Studies represented by a circle proportional to their weight in the analysis. (Studies with five categories have more impact on slope)

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Forest plots were used to provide illustration of the calculated OR per study as well as the overall pooled effect of all studies in the plot. The forest plot is a graphical presentation of the results that displays the point estimate and confidence interval of the effect observed in each study along with the summary estimate and its confidence interval (Dohoo et al., 2003).

A forest plot of the studies of dystocia was shown in Figure (5).

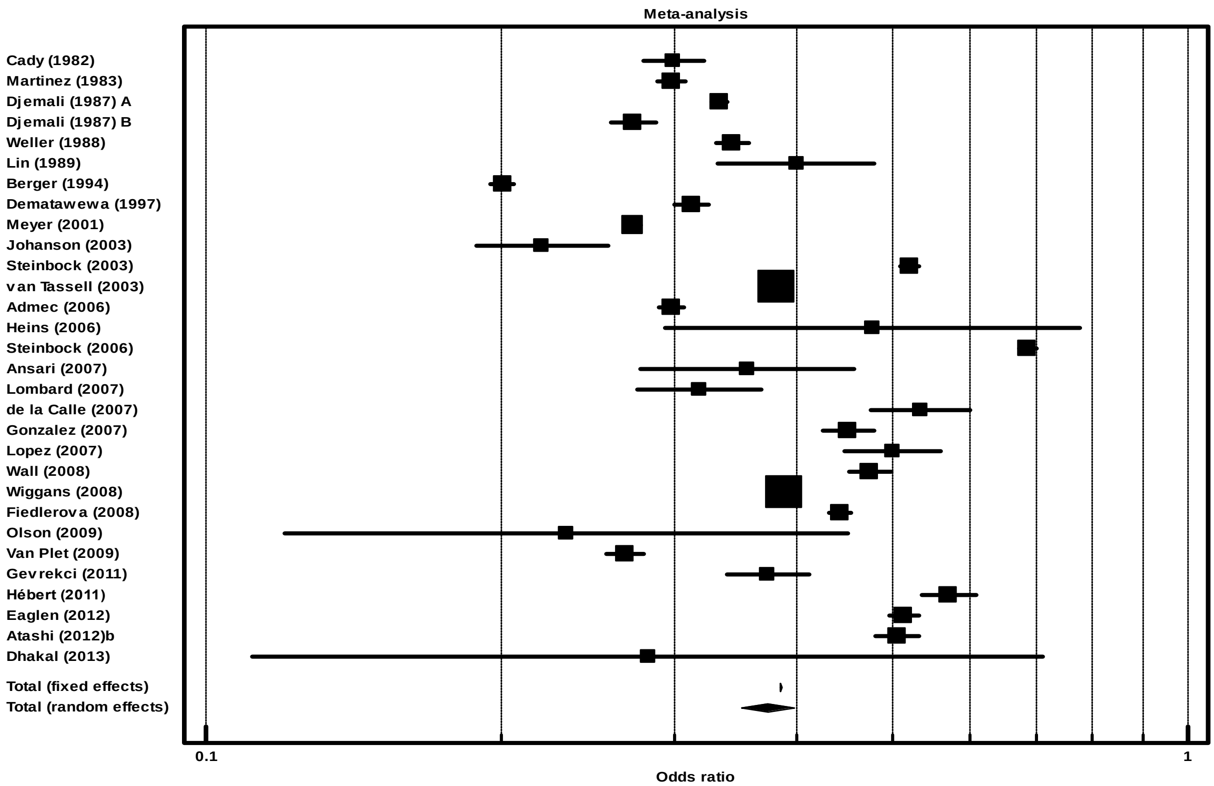

Figure 5: Forest plots of dystocia studies

Table 5: Odds ratio of stillbirth for different studies

Study name	Odds ratio	Lower limit	Upper limit	Z-Value	P	Weight (Random)	Weight (Fixed)
Weller et al., (1988)	2.09	2.02	2.17	41.44	0.00	5.81	1.14
Harber et al.,(1992)	2.30	2.28	2.32	204.57	0.00	5.83	21.80
Meyer et al., (2001)	2.06	2.02	2.10	72.75	0.00	5.82	3.68
Johanson and Berger(2003)	2.98	2.36	3.77	9.20	0.00	5.24	0.03
Steinbock et al., (2003)	2.75	2.68	2.83	77.20	0.00	5.82	2.10
Bar and Ezra (2005)	1.89	1.65	2.17	9.00	0.00	5.60	0.07
Adamec et al.,(2006)	2.02	1.92	2.13	26.48	0.00	5.80	0.51
Heins et al., (2006)	1.28	0.82	2.00	1.08	0.00	4.12	0.01
Steinbock (2006)	2.15	2.11	2.20	72.36	0.00	5.82	3.23
Bicahlo et al.,(2007)	2.90	2.52	3.34	14.87	0.00	5.60	0.07
Lombard et al., (2007)	2.22	1.88	2.61	9.60	0.00	5.53	0.05
Cole et al., (2007)	1.26	1.25	1.27	62.22	0.00	5.83	26.17
Wall et al., (2008)	2.19	2.06	2.33	24.65	0.00	5.78	0.36
Wiggans et al., (2008)	2.62	2.61	2.64	317.36	0.00	5.83	39.31
Olson et al., (2009)	4.93	2.04	11.90	3.55	0.00	2.23	0.00
Atashi (2011)	1.84	1.58	2.14	7.94	0.00	5.57	0.06
Atashi et al(2012b)	2.21	2.13	2.30	40.60	0.00	5.81	0.95
Eaglen et al., (2012)	2.74	2.59	2.89	36.06	0.00	5.79	0.47
Dhakal et al., (2013)	1.25	0.51	3.08	0.49	0.00	2.16	0.00
Fixed	2.06	2.05	2.07	379.89	0.00		
Random	2.18	1.84	2.58	9.11	0.00		

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Effect of Primiparous and Multiparous on Stillbirth

Results shows that I^2 = 99.92, and P = 0.000. Estimated OR with random model for stillbirth is OR = 2.18, 95% CI 1.84 to 2.58 and the corresponding estimates in fixed model is OR = 2.06, 95% CI 2.05 to 2.07 (Table 5).

Duval and Tweedie (2000) reported that: when there was no missing study in the funnel plot, the observed and adjusted OR is identical.

Figure (6) shows that there was no bias as the studies were distributed symmetrically. The estimate of observed and adjusted OR are identical. (OR = 2.18, 95% CI 1.84 to 2.58).

Egger's linear regression method was applied and results shows that the intercept (β0) is 1.76, 95% CI (21.70, 25.24), with t = 0.158, df = 17. The one-tailed p-value is 0.43, and the two-tailed p-value is 0.87. Begg and Masumdar rank correlation was used also and the Tau value was −0.29, P (one tailed) = 0.04 and P (two tailed) = 0.08.

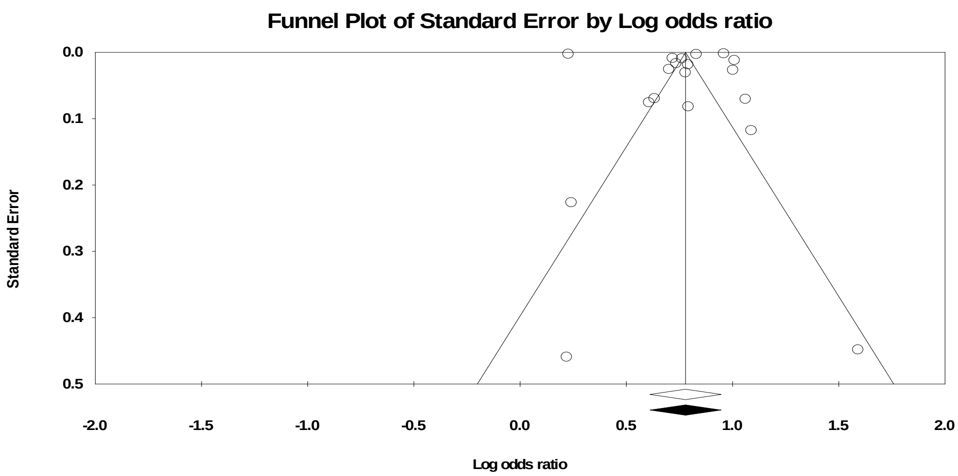

Figure 6: A funnel plot of studies effect size against their standard error for stillbirth

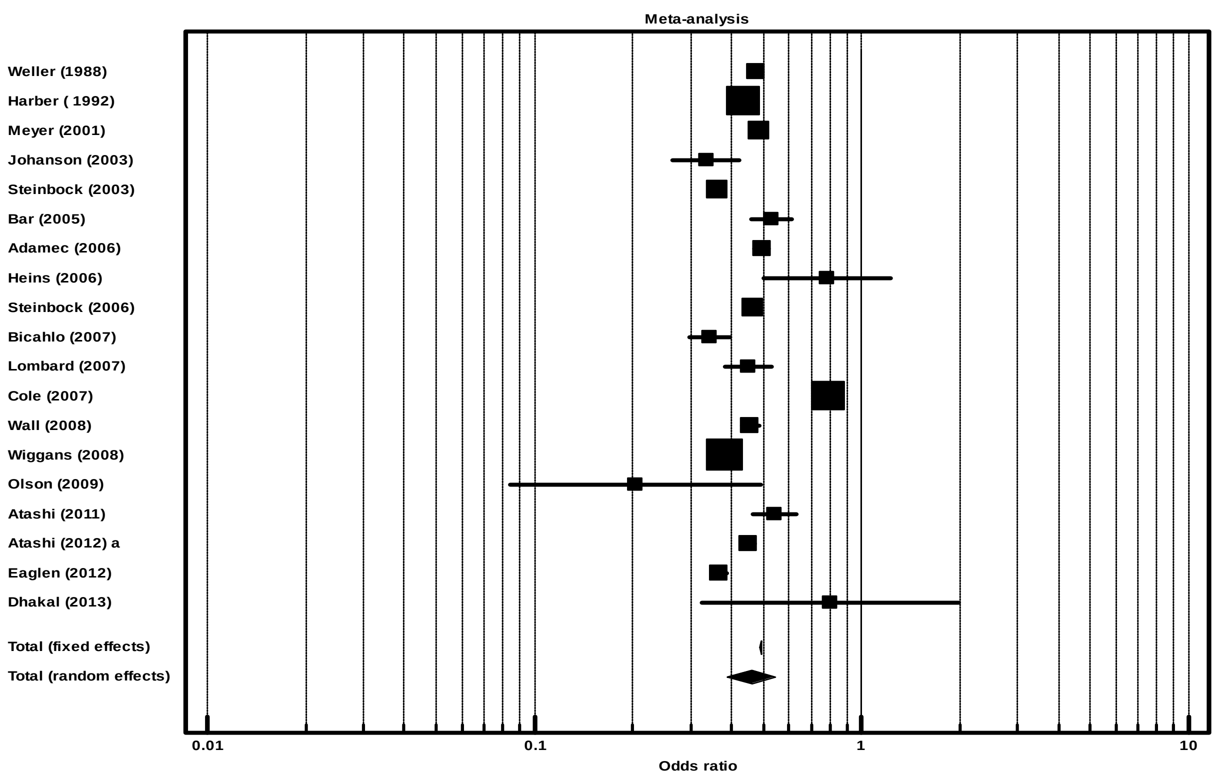

Figure 7: Forest plots of the stillbirth studies

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It's obvious that the heterogeneity is detected in stillbirth but when there is heterogeneity that cannot readily be explained, one analytical approach is to incorporate it into a random effects model. In such case, we were unable to define the causing factors and then unable to apply meta–regression. A Forest plot for stillbirth was shown in Figure (7).

Results revealed that the test of heterogeneity confirmed the existance of a substantial heterogeneity in dystocia and stillbirth. So the estimation of OR by random model is more accurate in two mentioned traits. The OR of dystocia (2.68) is higher than stillbirth (2.18) which means that heifers is more likely to have dystocia as compared with stillbirth. Although the studies in dystocia were more as compared with stillbirth, results show that bias associated with estimation of OR was present in dystocia only. The current study confirmed that primiparous cows were most likely to have dystocia and stillbirth as compared with multiparous cows. Results also indicate that differentiation can be made among primiparous and multiparous cows in the risk of having dystocia and stillbirth. These differences among cows could be useful to aid the better management to minimize their harmful effects in the dairy herds; particularly both traits have a low heritability (Lin et al., 1989).

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