Cloud Publications
International Journal of Advanced Veterinary Science and Technology
2013, Volume 2, Issue 1, pp. 64-71, Article ID Sci-137
ISSN 2320-3595

Review Article | Open Access

Economic Analysis of Metabolic Diseases in Bovines: A Review

Senthilkumar V., A. Mohamed Safiullah, G. Kathiravan, M. Subramanian and K. Mani

Department of Animal Husbandry Economic, Veterinary College and Research Institute, Namakkal, Tamil Nadu, India

Correspondence should be addressed to Senthilkumar V., senthilahe@gmail.com

Publication Date: 27 September 2013

Article Link: http://scientific.cloud-journals.com/index.php/IJAVST/article/view/Sci-137

Abstract In a dairy farming, among more diseases, metabolic/calving diseases are of great concern to dairy producers worldwide. Dairy cattle metabolic disorders, which are disease related to disturbance of one or more metabolic processes in the organism. This paper presents an overview the evaluation of the economic impact of metabolic diseases in bovines. References will be limited to economics rather than general focus, with emphasis on the most current reviews. The search was performed with the key words being part of the title, descriptors and / or appearing anywhere in the reference in order to find as many papers dealing with metabolic diseases as possible. The important metabolic diseases such as ketosis, milk fever and downer cow complex are discussed under two headings viz., prevalence/incidence rate and quantification of economic loss.
Keywords *Downer Cow Complex, Incidence, Ketosis, Milk Fever, Prevalence*

1. Introduction

The prevalence of animal diseases in the world has been reduced in the last four decades due to its economic importance; there are still some of the livestock diseases that cause reduction in production efficiency leads severe economic losses (Johnchristy and Thirunavukkarasu, 2006; Nagategize and Kaneene, 1985). An assessment of a disease based on economics is not only due to lack of available parameters or data e.g. quantifiable data on weight loss, milk loss, extra labour cost, medicine and treatment charges, calving and fertility problems due to a disease, but it is also due to the setback of validation for such models (Singh and Shiv Prasad, 2008). Disease outbreak among dairy cows constitutes a problem both in terms of financial losses (value of dead cow, decreased production and extra labour) and compromised animal welfare (suffering before death or euthanasia), (Thomsen and Houe, 2006). The economic implications of animal diseases are becoming increasingly important at both farm and national levels, as diseases represent avoidable waste of scare resources, especially cross breeds, as they stand more susceptible to diseases, hardships and contingencies peculiar climate (Thirunavukkarasu *et al*., 2010a).

Metabolic disorders of cattle are a group of diseases that affect dairy cows immediately after parturition. There are several metabolic disorders identified in dairy cows during the first month after parturition. The metabolic diseases such as ketosis, milk fever and downer cow syndrome are the most common expensive disease entities in lactating dairy animals. This disease condition cause severe economic losses in terms of heavy reduction in milk yield and impaired reproductive performance. The estimation of the effects of these diseases on milk production, fertility and survival is of great importance to assess cost–benefits of diagnosis, treatments and prevention efforts. But the quantifying economic losses of metabolic diseases in dairy farming were rarely addressed in developing countries. Quantification of economic losses due to metabolic disease is overall view of the impact of these diseases and can contribute estimating the extent of the losses to be avoided. The comprehensive reviews of major metabolic diseases in bovines were studied and more focus on incidence, prevalence rate and quantification of economic losses. We have reviewed major achievements as we see them in understanding economic losses of lactation ketosis, milk fever and downer cow complex. References will be limited to economics rather than general focus, with emphasis on the most current reviews.

2. Materials and Methods

All studies on metabolic diseases among dairy animals published in peer–reviewed journals were identified using a number of different literatures. No restrictions regarding year of publication were imposed and worldwide estimation. The literature search was based on the keywords such as metabolic disease, ketosis, milk fever and downer cow. The search was performed with the keywords being part of the title, descriptors and / or appearing anywhere in the reference in order to find as many papers dealing with metabolic diseases as possible. This studies including information solely about incidence, prevalence rate and quantification of economic losses in dairy farms. After the initial search of the literature, it was decided to include studies in other countries also; therefore studies from outside India were included. Hereafter, the publications were analysed for information on metabolic diseases as well as associated with economic losses.

3. Results and Discussion

3.1. Ketosis

Ketosis is simply a condition marked by increased levels of circulating ketone bodies without the presence of the clinical signs of ketosis. Ketosis can cause economic losses through decreased milk production and association with pre parturient diseases (Ardvan Nowroozi *et al*., 2011).

A) **Prevalence and Incidence**

(Dohoo and Martin, 1984a) found that the prevalence of ketosis was 12.10 percent in cows and the incidence rates of ketosis have been reported to be between 11.10 and 12.10 percent (Erb and Grohn, 1988; Rasmussen *et al*., 1999; Ostergaard and Grohn, 2000), further they observed that the peak prevalence of hyperketonemia occurred in the third and fourth week of lactation and on an individual herd basis reported that herd prevalence in cows from 0 to 65 days in milk varied from 0 percent to 33.9 percent in a study where the overall prevalence was 12.1 percent ketosis, the number of cows affected 6570 (5.6 percent), 4409 (7.9 percent) and 6769 (12.7 percent) in the parity 1, 2, 3 respectively. Most authors report that the incidence of ketosis increases with age and that the peak incidence may be in cattle in lactations stage from third to six (Shaw 1956; Overby *et al*., 1974; Erb and Martin, 1978; Lindstram *et al*., 1984; Bendixen *et al*., 1987; Grohn *et al*., 1989). It has been reported that overall prevalence of subclinical ketosis ranges from 6.9 percent to 14.1 percent in the first two months of lactation (Andersson and Emanuelson, 1985; Nielen *et al*., 1994; Duffield *et al*., 1997).

However, prevalence as high as 34 percent has been reported (Kauppinen 1983; Duffield *et al*., 1998; Duffield, 2000). The overall prevalence of ketosis was 9.38 percent in cows and 2.92 percent in buffaloes, observed by (Thirunavukkarasu *et al*., 2010b) in Tamil Nadu in the year 2008, further they observed low prevalence of ketosis in cows of Erode and Coimbatore districts of Tamil Nadu could be attributed to the relatively better feeding management in these districts.

(Emery *et al*., 1964) suggested that 50 percent of all lactating cows go through a stage of subclinical ketosis in early lactation. (Herdt *et al*., 1981) found higher milk yields put cows at an increased risk of developing subclinical ketosis. Increased milk production may be associated with increased fat mobilization and a greater risk of hyperketonemia (Lean *et al*., 1992). (Kauppinen, 1984) reported that subclinical ketotic cows had significantly higher annual milk yields than non ketotic cows. In 507 untreated Holstein cows and heifers from 25 dairy herds, the cumulative incidence over the first 9 weeks of lactation was 59 percent and 43 percent (Duffield *et al*., 1998). Ardavan Nowroozi Asl et al., 2011 studied the prevalence of subclinical ketosis in dairy cattle in the South Western Iran and observed 97 percent of the cows experienced at least one episode of subclinical ketosis during the sixth week post partum period and that there was a statistical relation between the prevalence of sub clinical ketosis and milk production.

B) **Economic Loss**

The economic loss of one cow with subclinical ketosis is estimated to be $78 U.S (Geishauser *et al*., 2001). A five percent and the disease costs $145.00, a 100 cow dairy herd would have a cost of clinical ketosis of $725 in a year. Whereas, an average of 100 dairy cows were suffered with subclinical ketosis and the incidence rate of 41 percent with an annual cost of $3198 (Todd Duffield, 2003).

The loss due to ketosis was estimated by (Thirunavukkarasu *et al*., 2010b) and reported that Rs. 577.09 per affected cow, which included the cost of medicines (Rs. 262.99, 45.57 percent), Veterinarian's fee including additional labour cost (Rs. 224.98, 38.99 percent) and expenses on feed supplements (Rs. 89.12, 15.44 percent). However, the loss per affected buffalo was slightly lesser at Rs. 510.80 of which Rs. 240.80 (47.14 percent), Rs. 187.50 (36.71 percent) and Rs. 82.50 (16.15 per cent) were contributed by medicine cost, veterinarian's fee (including additional labour cost) and cost of feed supplements, respectively.

3.2. Milk Fever

It is an afebrile hypocalcaemia disease of cattle usually associated with parturition and initiation of lactation. This disease has been known by a number of terms including parturition paresis, milk fever, parturient apoplexy, eclampsia and paresis peurperalis (Littledike *et al*., 1981). Further, increasing production of milk after calving places an enormous demand for glucose and minerals at a time when feed intake would not have reached its peak, leading to draining of glucose and calcium from the blood and leaving the milch animal's metabolism under severe stress, as transitions to lactation (Bethard and Smith, 1998). Clinical hypocalcaemia before, during or after calving (Bar and Ezra, 2005). Milk fever is a metabolic disease occurring in dairy animals during per parturient period. Thus, milk fever management is economically most important, as it results in not only reduction in milk production, but also loss of animals (Thirunavukkarasu *et al*., 2010a).

A) **Incidence**

The incidence is highest in the Jersey breed (Littledike, 1974). (Horst, 1986) has also reported occurrence of milk fever at the rate of 5 to 10 percent in the USA. (Rajala-Schultz and Grohn, 1999) reported that 23,416 Ayrshire cows affected by milk fever. The percentage of incidence for milk fever

is 0.0 percent (6570), 0.1 percent (4409) and 2.6 percent (6769) for respectively, 1, 2, and 3 lactation. The total milk loss in third lactation stage is 141.6 kg. (Thirunavukkarasu *et al*., 2010a) has revealed that of the total 3774 cows in five milk shed districts of the State of Tamil Nadu, 516 (13.67 percent) were affected by milk fever and of 342 buffaloes 41 (11.99 percent) suffered with milk fever.

B) **Economic Loss**

The economic loss from milk fever in Sweden was estimated in 1969 to be atleast 10 million Swedish crowns annually (Jonsson, 1960). Payne in 1966 listed the national estimate of depreciation due to milk fever in Great Britain at 1, 61,000 pounds annually. Estimates of losses appear to be much too low it losses had been evaluated as previously reported by (Leeh *et al*., 1964). They reported that cows that have had the disease depreciated by an average of 35 pounds in market value and also suffered a market reduction in productive life. In France, 1, 50,000 cases of milk fever were reported in 1959 and a 10 million franc loss was estimated (Lavor *et al*., 1961). (Rajala-Schultz *et al*., 1999) have reported that reduction in the milk yield of cows affected by milk fever ranged from 1.1 kg/day to 2.9 kg/day, depending on parity and the time taken for diagnosis. (Hutjens, 2003) has reported that the average loss due to milk fever per animal was of $334, due to the loss of 1100 lb of milk and 5 days of extra days open. The economic loss was estimated at $334 per occurrence milk losses were estimated to be 142 kg in cows of parity third or more in a study on Israeli Holstein cows that calved between June 2002 and December 2003 (Bar and Ezra, 2005). (Hutjens, 2003) observed that 8 percent of the affected animals died and 12 percent of them were culled.

The average loss per animal due to the treatment of milk fever was higher at Rs. 618 for a cow than for a buffalo, Rs. 488, the average loss being Rs. 608 (Thirunavukkarasu *et al*., 2010). (Guard, 1996) was estimated 334, based on the cost of treating clinical cases and production losses. The average loss due to reduction in milk yield per affected animal was also higher for a cow (Rs. 346) than a buffalo (Rs. 177).

3.3. Downer Cow Complex

(Fen wick, 1969) in Australia defined a downer as any cow with milk fever that did not get up within 10 min of first treatment with intravenous calcium, (Bjorsell *et al*., 1969) from Sweden considered a downer cow to be one that had not risen within 24 hours after first treatment with calcium for Milk fever. Terms used to describe these various syndromes are ‘downers’, ‘alert downers’, ‘a typical milk fever’ or ‘creeper cows’ and ‘fat cow syndrome’ (Morrow, 1976; Morrow *et al*., 1979). Downer cow diseases are complications resulting from milk fever with demonstrable muscle, tendon or nerve injuries (Littledike *et al*., 1981). Other syndromes in this disease complex are not as easy to characterize indeed, various combinations of diseases may be in the same. Downer cow syndrome has no universal definition. We favour the definition used by (Cox *et al*., 1986), a downer cow is one down for at least 24 hours without apparent reason for being down.

A) **Incidence**

In the Ontario case series, 75 out of 82 downer cows had been treated for milk fever, Seventy out of 82 cases occurred from November to April and 82 (67 percent) downer cows died or were slaughtered (Curtis *et al*., 1970). Low cholesterol concentration in serum (Less than 100 mg/100 ml) 8 weeks before calving was associated with a 70 percent incidence of downer cow in a German study (Sommer, 1975). In a feeding trial, 6 of 8 downer cows failed to respond to treatment (Julien, 1977).

Dry cows fed only on 8 percent crude protein ration had a 7 percent metabolic disease incidence and no alert downers (Littledike *et al*., 1981). A mail survey of 723 Minnesota dairy herds with 34,650 cows per year at risk found a rate of 21.4/1000 cow per year at risk. Unpublished data from Cornell

University using data from the study described in path model of reproductive disorders and peroformance, include 28 downer cases in 7767 lactations from 34 herds (4/1000 cow-year). Inspite of the apparent variety of the syndrome, it is important because of the devastating prognosis for the cow Minnesota farmers reported that of cows who were down (and who neither were slaughtered in less than one day nor died in less than four days), 23 percent were slaughtered, 44 percent died and only 33 percent recovered. Cows that were over conditioned during the dry period and fed a ratio of 15 percent crude protein had a 69.4 percent incidence of metabolic diseases and a 31 percent incidence of the alert downer cows. The only evidence regarding milk yield as a risk factor for downer cow syndrome is the reported impression of Minnesota farmers that their downer cows were 48 per cent high producers, 46 percent average producers and only 6 percent low producers (Cox *et al*., 1986). The incidence rate of downer cows among milk fever cows (4 per cent to 35 percent) is at least 10 times higher than the crude rates estimated for the general population of dairy cows. Unpublished data from 7767 lactations in private herds around Cornell University show that 10 out of 28 downer cows (36 percent) also had a clinical milk fever diagnosis.

B) **Economic Loss**

Treatment of cows severely affected with fat cow syndrome is expensive, time consuming and often ineffective. Practical control of these diseases must be affected through management. There is lack of evidence regarding quantification of economic losses due to downer cow syndrome in dairy cattle.

4. Conclusion

In the literature, there are wide variations in the reported prevalence of bovine ketosis. These variations may be attributed to the differences in both the method and the material of the measurement used in determining the prevalence of bovine ketosis. Milk fever is uncommon before the third parturition and incidence is highest at the fifth or sixth parturition. Thus, cows are most likely to develop milk fever during their most productive years. Economic losses due to milk fever occur due to expenditure on treatment of disease affected animals and reduction in quantity of milk. Losses from this disease are difficult to quantitate because of the many indirect costs. Example, some owners cull older, high producing cows from a herd, because of a history of repeated case of milk fever. There is little documentation of the incidence rate of downer cow syndrome.

Reference

Anderson L. and Emanuelson U. *An Eqidemiological Study of Hyperketonaemia in Swedish Dairy Cows: Determinants and the Relation to Fertility.* Preventive Veterinary Medicine. 1985. 3; 449-462.

Ardavan Nowroozi Asl, Saeed Nazifi, Abbas Rowshan Ghasrodashti and Ahad Olyaee. *Prevalence of Subclinical Ketosis in Dairy Cattle in the South Western Iran and Detection of cut off Point for NEFA and Glucose Concentrations for Diagnosis of Subclinical Ketosis*. Preventive Veterinary Medicine. 2011. 100; 38-43.

Bar D. and Ezra E. *Effects of Common Calving Diseases on Milk Production in High-Yielding Dairy Cows*. Israel Journal of Veterinary Medicine. 2005. 60 (4).

Bendixen P.H., Vilson B., Ekesbo I. and Astrand D.B. *Disease Frequencies in Dairy Cows in Sweden, IV. Ketosis*. Preventive Veterinary Medicine. 1987. 5; 99-109.

Bethard G. and Smith J.F., 1998: *Controlling Milk Fever and Hypocalcaemia in Dairy Cattle: Use of Dietary Cation-Anion Difference (DCAD) in Formulating Dry Cow Rations*. Technical Report 31, Agricultural Experiment Station, Cooperative Extension Service, College of Agriculture and Home Economics, New Mexico State University, 1.

Bjorsell K.A., P. Holtenius and S.O. Jacobsson. *Studies on Parturient Paresis with Special Reference to the Downer Cow Syndrome*. Acta Veterinary Scand. 1969. 10; 36.

Cox V.S., W.E. Marsh, G.R. Steuernagel, T.F. Fletcher and J.S. Onapito*. Downer Cow Occurrence in Minnesota Dairy Herds*. Preventive Veterinary Medicine. 1986. 4; 249.

Curtis R.A., J.F. Cote and R.A. Willoughby. *The Downer Cow Syndrome. A Complication, Not a Disease*. Modern Veterinary Practice. 1970. 51; 25.

Dohoo I.R. and Martin S.W. *Disease, Production and Culling in Holstein – Friesian Cows. II. Age, Season and Sire Effects*. Preventive Veterinary Medicine. 1984b. 2; 665-670.

Dohoo I.R and S.W. Martin. *Subclinical Ketosis: Prevalence and Associations with Production and Disease*. Canadian Journal of Comparative Medicine. 1984a. 48; 1-5.

Duffield T. *Subclinical Ketosis in Lactating Dairy Cattle*. Veterinary Clinical North American Food Animal Practice. 2000. 16; 231-253.

Duffield T.F., Kelton D.F., Leslie K.E., Lissemore K.D. and Lumsden J.H. *Use of Test Day Milk Fat and Milk Protein to Detect Subclinical Ketosis in Dairy Cattle in Ontari*. Canadian Veterinary Journal. 1997. 38; 713-718.

Duffield T.F., Sandals D., Leslie Ke., Lissemore K.D., McBride B.W., Lumsden J.H., Dick P. and Bagg R. *Efficacy of Monensin for the Prevention of Subclinical Ketosis In Lactating Dairy Cows*. Journal of Dairy Science. 1998. 81; 2866-2873.

Emery R.S., Burg N., Brow, L.D. and Blank G.N. *Detection, Occurrence and Prophylactic Treatment of Borderline Ketosis with Propylene Glycol Feeding*. Journal of Dairy Science. 1964. 47; 1074-1079.

Erb H.N and Martin S.W. *Age, Breed and Seasonal Patterns in the Occurrence of Ten Dairy Cow Diseases: A Case Control Study*. Canadian Journal of Comparative Medicine. 1978. 42; 1-9.

Erb H.N and Y.T. Grohn. *Epidemiology of Metabolic Disorders in the Periparturient Dairy Cow*. Journal of Dairy Science. 1988. 71; 2557-2571.

Fenwick D.C. *Parturient Paresis (Milk Fever) of Cows: 1. the Response to Treatment and the Effect of the Duration of Symptoms*. Australian Veterinary Journal. 1969. 45; 111.

Geishauser T., K. Leslie and K. Kelton, 2001: *Monitoring Subclinical Ketosis in Dairy Herds. Comp*. Cont. Ed. 23; 65-71.

Grohn Y. Erb, H.N. McCulloch and C.E. Saloniemi H.S. *Epidemiology of Metabolic Disorders in Dairy Cattle: Association among Host Characteristics, Disease and Production*. Journal of Dairy Science. 1989. 72; 1876-1885.

Herdt T.H., Stevens J.B. Olson and W.G. Larson V. *Blood Concentrations of B-Hydroxybutyrate in Clinically Normal Holstein-Friesian Herds and in those with a High Prevalence of Clinical Ketosis*. American Journal of Veterinary Research. 1981. 42; 503-506.

Horst R.L. *Regulation of Calcium and Phosphorous Homeostasis in Dairy Cows.* Journal of Dairy Science. 1986. 69; 604.

Hutjens M. *An Alternate to Metabolic Disorders: Looking at Hypocalcaemia, Dairy Decision Column*. University of Illinois, Urbana. 2003. 18 Feb.

JohnChristy R. and M. Thirunavukkarasu. *Emerging Importance of Animal Health Economics–A Note*. Tamil Nadu Journal of Veterinary and Animal Sciences. 2006. 2 (3) 113-117.

Jonsson G. *On the Etiology and Pathogenesis of Parturient Paresis in Dairy Cows.* Acta Agricultural Scand. 1960. 8; 1.

Julien W.E., H.R. Conrad and D.R. Redman. *Influence of Dietary Protein on Susceptibility to Alert Downer Syndrome*. Journal of Dairy Science. 1977. 60; 210.

Kauppinen K. *Prevalence of Bovine Ketosis in Relation to Number and Stage of Lactation.* Acta Veterinary Scand. 1983. 24; 349-361.

Kauppinen K. *Annual Milk Yield and Reproductive Performance of Ketotic and Non-Ketotic Dairy Cows*. Zentralbi. Veterinamed. 1984. A 31; 694-704.

Lavor P., M. Brochart and M. Theret. *Enquete Sur Lafieure Vitulaire et al Tetanie D'herbage Des Bovines En France*. Econ. Med. Animal. 1961. 2; 5.

Lean I.J., Bruss M.L., Baldwin R.L. and Trout H.F. *Bovine Ketosis a Review. Biochemistry and Prevention*. Veterinary Bulletin. 1992. 62; 1-14.

Leech F.B., M.P. Vessey and W.D., Macrage. *Animal Diseases Surveys*. Rep. No. 3. Disease, Wastage and Husbandry in the British Dairy Herd. Rep, Nat. Survey in 1958-1959. 1964. (3) 5-10.

Lindstram U.B., Bonsdorff M.V. and Syvajarvi J. *Factors Affecting Bovine Ketosis And Its Association with Non-Return Rate*. Journal of Science Agric. Soc. Finland. 1984. 55; 497-506.

Littledike E.T., 1974: *Parturient Hypocalcaemia, Hypomagnesaemia, Mastitis-Metritis-Agalactia Complex of Swine*. In: B.L. Larson and V.R. Smith, Eds. Lactation–A Comprehensive Treatise. Vol. II Academic Press, New York, NY. 335.

Littledike E.T., J.W. Young and D.C. Beitz. *Common Metabolic Diseases of Cattle: Ketosis, Milk Fever, Grass Tetany and Downer Cow Complex*. Journal of Dairy Science. 1981. 64; 1465.

Morrow D.A. *Fat Cow Syndrome*. Journal of Dairy Science. 1976. 59; 1625.

Morrow D.A., D. Hillman and A.W. Dode. *Clinical Investigation of a Dairy Herd with Fat Cow Syndrome*. Journal of American Veterinary Medicine Association. 1979. 174; 161.

Ngategize P.K and Kaneene J.B. *Evaluation of the Economic Impact of Animal Diseases on Production: A Review.* Veterinary Bulletin. 1985. 55; 153-161.

Nielen M., Aarts M.G.A., Jonkers A.G.M., Wensing T. and Schukken Y.H. *Evaluation of Two Cow Side Tests for the Detection of Subclinical Ketosis in Dairy Cows*. Canadian Veterinary Journal. 1994. 35; 229-232.

Ostergaard S. and Y.T. Grohn. *Concentrate Feeding, Dry Matter Intake and Metabolic Disorders in Danish Dairy Cows*. Livestock Production Science. 2000. 65; 107-118.

Overby I., Aas Hansen, M. Jonsgard, K. Sognen and E. Bovine Ketosis*. Occurrence and Incidence in Herds Affected by Ketosis in Eastern Norway 1967-1968*. Nord. Veterinary Medicine. 1974. 26; 353-361.

Payne J.M. *Outlook on Milk Fever*. Outlook Agriculture. 1968. 5; 266.

Rajala-Schultz P.J., Y.T. Grohn and C.E. McCulloch. *Effects of Milk Fever, Ketosis and Lameness on Milk Yield in Dairy Cows*. Journal of Dairy Science. 1999. 82 (2) 288-294.

Rajala-Schultz P.J and Y.T. Grohn. *Culling of Dairy Cows: Part 1. Effects of Diseases on Culling in Finnish Ayrshire Cows*. Preventive Veterinary Medicine. 1999. 41; 195-208.

Rasmussen L.K., B.L. Nielsen, J.E. Pryce, T.T. Mottram and R.F. Veerkamp *Risk Factors Associated with the Incidence of Ketosis in Dairy Cows*. Journal of Animal Sciences. 1999. 68; 379-386.

Shaw J.C. *Ketosis in Dairy Cattle- A Review*. Journal of Dairy Science. 1956. 39; 402-434.

Singh B. and Shiv Prasad. *Modelling of Economic Losses Due to Some Important Diseases in Goats in India*. Agricultural Economics Research Review. 2008. 21; 297-302.

Sommer H. *Preventive Medicine in Dairy Cows*. In: Veterinary Medical Review. N.G Elmert Universitats and Verlagsbuckhandlung Marbrglahn. 1975. 42.

Thirunavukkarasu M., G. Kathiravan, A. Kalaikannan and W. Jebarani. *Quantifying Economic Losses Due to Milk Fever in Dairy Farms*. Agricultural Economics Research Review. 2010a. 23; 77-81.

Thirunavukkarasu M., G. Kathiravan, A. Kalaikannan and W. Jebarani. *Prevalence of Ketosis in Dairy Farms–A Survey in Tamil Nadu*. Tamil Nadu journal of Veterinary and Animal Sciences. 2010b. 6 (4) 193-195.

Thomsen P.T. and H. Houe. *Dairy Cow Mortality a Review*. Veterinary Quarterly. 2006. 28 (4) 122-129.

Todd Duffield, 2003: *Minimizing Subclinical Metabolic Diseases*. Tri-State Dairy Nutrition Conference. 1-13.