https://doi.org/10.56093/ijans.v90i11.111483

Indian Journal of Animal Sciences **90** (11): 1447–1452, November 2020/Article

Epidemiology, economic losses due to Haemorrhagic Septicemia and cost-benefit analysis of interventions in dairy animals of Punjab

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Received: 14 January 2020; Accepted: 17 March 2020

ABSTRACT

The epidemiological features and financial losses due to Haemorrhagic Septicemia (HS) in dairy animals of Punjab were studied using the primary data collected from 720 livestock owners/ dairy farms. The overall incidence and case fatality rate (CFR) risk of HS among dairy animals was 5.45 and 45.15%, respectively. Incidence risk of HS on the species basis varied significantly and was observed highest in buffaloes (6.27%), followed by cross bred (4.67%) and indigenous cattle (3.91%). The overall financial loss due to HS per affected animal per year was ₹ 5111.64±482.32. However, the mean economic losses per animal per year affected varied significantly among different categories of animals, and was highest in buffalo (₹ 7265.08±735.27), followed by cross bred (₹ 5799.55±447.48) and lowest in indigenous cattle (₹ 2270.30±405.22). At species level, the largest component of the economic losses were due to mortality loss of animals (69.42% in cross bred, 63.15% in indigenous cattle and 70.40% in buffaloes), followed by treatment cost and reduction of milk yield. On benefit cost analysis of control measures, higher BCA ratio was observed in buffalo, followed by crossbred and indigenous cattle. It may be concluded that poor understanding of the disease and lack of effective control measures such as timing and potency of vaccination are some of the factors impacting upon the economics of dairy farming in Punjab state. Training and extension activities should backup the efforts to control this dreadful disease.

Keywords: Animal, Buffalo, Cattle, Financial loss, Incidence

Haemorrhagic Septicemia (HS, locally known as “Gal Ghotu” is an acute, fatal bacterial disease of bovines caused by *Pasteurella multocida*, especially in tropical countries of Asia and Africa (DeAlwis 1992, Ahmed 1996). The organism remains in the upper respiratory tract as a commensal and causes the disease when the animal undergoes stress. It is clinically characterized by an initial phase of temperature elevation (often unnoticed), followed by a phase of respiratory involvement, and a terminal phase of septicemia and recumbency leading to death. Important factors associated with higher incidence of HS is moist, humid conditions along with high ambient temperature, high buffalo population density, and extensive free grazing system of management, where large herds graze freely in common pastures and are kept in paddocks together at night. Buffalo is highly susceptible to HS as compared to cattle and once clinical signs appear, case fatality is nearly 100% leading to significant economic losses (FAO 1995). In endemic areas, some animals may act as latent carriers by carrying organisms in tonsils and are a source of infection for others (De Alwis 1990).

In India, HS is endemic with most of the states reporting the disease (Venkataramanan *et al*. 2005) and was ranked second to FMD during 1991–2010 in terms of number of reported outbreaks (Gajendragad and Uma 2012). It is characterized by an acute and highly fatal septicaemia with high mortality rate (~ 60%) and caused 50,000–55,000 deaths in animals leading to significant financial losses to farmers (Dua 2003, Singh *et al*. 2014a). There are limited studies about HS and its impact on dairy animals. Those few studied used secondary information for various time periods and assumed few factors/components such as mortality and culling levels, to estimate the losses for the entire country (Venkataramanan *et al.* 2005 and Singh *et al.* 2014a).

HS is a disease of considerable economic importance from farmer’s income point of view. However, no accurate estimates are available on the actual deaths due to HS and accurate measures to estimate the losses (both direct and indirect loses) associated with HS in dairy animals. The conditions for an early detection of the disease and hence its effective treatment are usually lacking in primitive husbandry systems. In organized farms, however, early detection and effective treatment are achieved through regular checking of rectal temperatures of in-contact animals. We believe that strengthening of disease reporting and surveillance systems in general will help to control this dreadful disease in bovines. Hence, the present study was

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attempted to address the gaps in the epidemiological, economic and control aspects of HS in Punjab through a primary survey of dairy farms.

MATERIALS AND METHODS

The present study was carried out in all the six agro-climatic zones of Punjab state described by Mahi and Kingra (2013), viz. Sub-mountainous undulating region (Zone I), Undulating plain region (Zone II), Central plain region (Zone III), Western plain region (Zone IV), Western region (Zone V) and Flood plain region (Zone VI) (Fig. 1).

Sampling schedule: Sampling was done by multistage stratified random sampling method. From each zone, two districts were taken randomly, and then from each selected district, two blocks were selected. From each selected block, 3 villages were taken for this study. Thus, the sampling comprised of 12 districts, 24 blocks and 72 villages. On the basis of a pre-survey, a list of farmers having at least 5 dairy animals, were prepared for each selected village. Thereafter, 10 livestock owners/households were randomly selected from each village. Thus, 720 livestock owners/households constituted the ultimate sampling units for the study. Out of 720 farmers, 112 reared cattle only, 472 reared buffalo only, and the remaining 136 farmers reared both cattle and buffalo.

The data pertaining to various aspects of HS were collected from the selected dairy farmers. The respondents were interviewed for data collection using interview schedule specially prepared for this purpose. The data on economic losses incurred by dairy farmers due to HS include

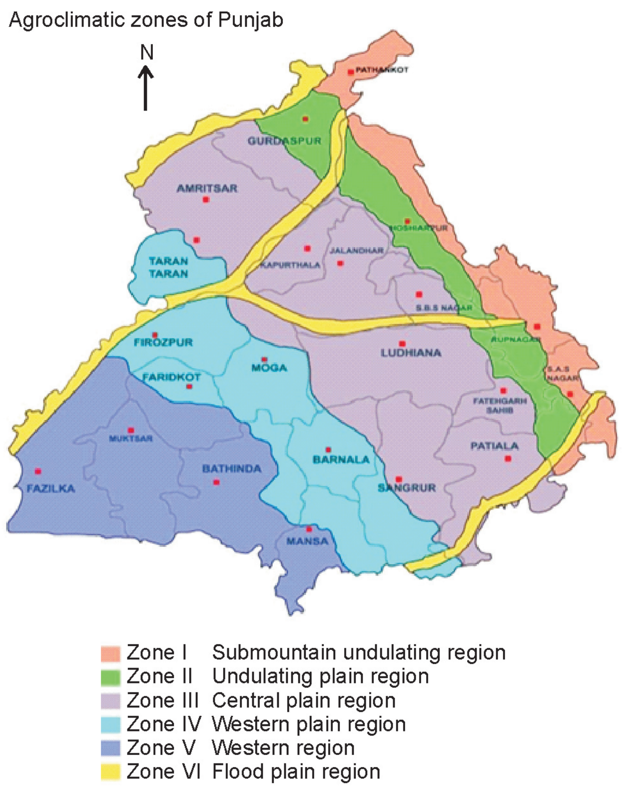


Fig. 1. Six different Agroclimatic zones of Punjab.

the milk loss, cost of treatment, mortality cost, miscellaneous cost (transportation of affected animal, rope, utensils, etc.) and extra labour engagement cost incurred to nurse the HS affected animals in different species were included using primary data and the formulae for calculating different losses are presented below.

Average milk yield reduction loss per animal

It includes reduction in milk during the disease condition

$$L_{MY} = \sum_{n=1}^{n}\left((E_i - A_i)\times D\times P\right)$$

where, LMY, Milk yield reduction loss due to HS per animal (₹); E_i, Expected milk yield in ith animal/day (litres); A_i, Actual observed milk yield in ith animal/day (litres); D, the average duration of illness in days of affected lactating cows in herd; P, prevailing price of milk (₹/litre); n, number of lactating animals recovered from HS.

Extra labour engagement cost per animal

$$E_L = \sum_{j=1}^{f}\left(\left[(D_j - P_j)/8\right]\times T\times W/n\right)$$

where, EL, Extra labour engagement cost for nursing the animal (₹); D_j, Manpower engaged during HS infected period in jth animal (h/day); P_j, Manpower engaged during pre-HS period jth animal (h/day); T, Average duration of illness (days); W, Wage rate/day (₹); f, Number of farms; n, Number of HS affected animals.

Since all the species of animals were reared by farmers under one roof, for the purpose of calculation of the extra labour cost it was assumed that the extra labour engaged for nursing the animal was equal across the different categories of animals. To convert the extra labour hours engaged in the farm into man days, the total labour hours was divided by 8, since eight hours of work is equivalent to one man day. However, for young animals, wage rate for extra labour engaged was considered half of the adult rate per day during the diseased condition.

Average mortality loss per animal

$$M_L = \frac{\left(\sum_{K=1}^{f} A_k \times P_k\right)}{n}$$

where, ML, mortality loss (₹); K, animal categories, viz. lactating cow, bull, heifer and calf; A, number of animals died due to HS; P, average animal value (₹); f, number of farms; n, total number of HS death cases.

Average treatment cost per animal

$$T_C = \frac{\left(\sum_{J=1}^{f} (V+M)\times Z\right)}{n}$$

where, T_c, cost of treatment (₹); V, veterinarian fees/visit (₹); M, medicine cost (₹); Z, visits by veterinarian (number); j, animal category; f, number of farms; n, number of HS affected animals.

Miscellaneous charges

This included transportation charges of affected animal carried to veterinary clinics, drought power loss, distress sale and charges for disposing dead animals. Since all the species of animals were reared by farmers under one roof, it was assumed that the charges would be same across the different species.

Statistical analysis: The data were analysed by one-way ANOVA followed by post-hoc test using SPSS software (v. 20). The probability value of less than 0.05 was considered significant. Data have been presented as Mean±SE.

RESULTS AND DISCUSSION

Economic losses due to HS: The overall incidence and CFR of HS among the dairy animals in Punjab were 5.4 and 45.2% respectively. The overall incidence and CFR of HS in Punjab has been reported elsewhere (Malik and Verma 2018). It was observed that incidence was highest in buffalo and lowest in indigenous cattle (Table 1). However, no difference in CFR was recorded among various categories of animals. The highest cases of cross-bred cattle infection were reported from Zone VI (5.8%), and lowest

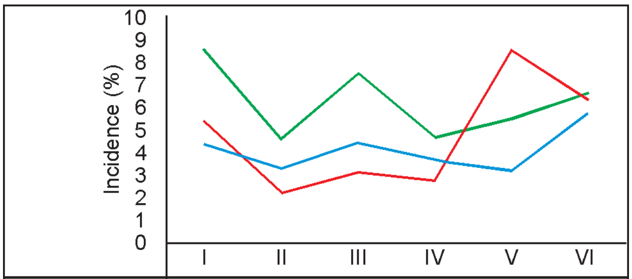
Table 1. Incidence risk and CFR due to HS on species basis of dairy animals in different agro-climatic zones of Punjab

Species basis	Category	Total Animals	Affected Animals	Prevalence (%)
Incidence rate (%)	Cross- bred Cattle	4639	217	4.7
	Indigenous cattle	920	36	3.9
	Buffalo	6472	387	6.23
	Overall $\chi2$ Value = 13.06*			
CFR (%)	Cross- bred Cattle	217	93	42.8
	Indigenous cattle	36	15	41.7
	Buffalo	387	181	46.8
	Overall $\chi2$ Value = 1.04 ns			

*(P<0.01) and indicates, significant difference; ns (P>0.05) indicate no significant difference.

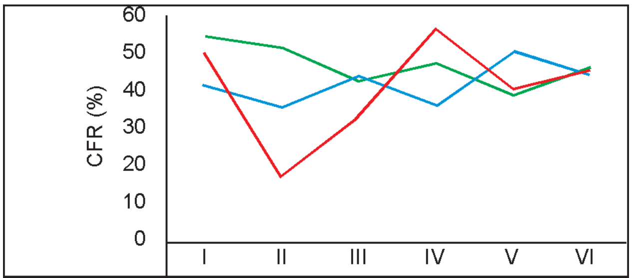
in Zone V (3.2%), whereas, within indigenous cattle, highest incidence of HS was reported from Zone V (8.6%) and lowest from Zone II (2.2%) (Fig. 2). The highest case fatality rate in cross-bred cattle was reported from Zone V (50.0%), and lowest in Zone II (35.3%); within indigenous cattle, highest incidence of HS was reported from Zone IV (57.1%) and lowest from Zone III (33.3%) and within buffaloes, the highest incidence of HS was reported from Zone I (53.7%) and lowest from Zone V (38.7%) (Fig. 3). The case fatality rate of HS was 28.08% in cattle and 42.87% in buffaloes as per Government of India data (2007–2011). However, much higher rates (57.38 and 56.63%, respectively) have also been reported (Singh *et al.* 2014). Sharma *et al.* (2007) have observed 2.85% morbidity and 24.27% case fatality rate during July, 2003 to June, 2005 in 22 outbreaks of HS in bovines in Haryana.

The component–wise and species- wise economic losses due to HS were evaluated and presented in Table 2. Among



	I	II	III	IV	V	VI
Crossbred	4.33	3.32	4.48	3.62	3.18	5.76
Indigenous	5.40	2.22	3.15	2.77	8.62	6.43
Buffalo	8.49	4.58	7.52	4.66	5.50	6.67

Fig. 2. Species wise incidence risk of HS in Punjab.



	I	II	III	IV	V	VI
Crossbred	41.66	35.29	43.90	35.71	50.00	44.03
Indigenous	50.00	16.67	33.33	57.14	40.00	45.45
Buffalo	53.70	51.21	42.55	47.36	38.70	46.02

Fig. 3. Species wise CFR risk of HS in Punjab.

the various categories of losses associated with HS in dairy animals, highest loss was due to mortality of animals followed by treatment expenses, sudden reduction in milk, extra labour charges during the illness period and miscellaneous cost among all the species as mentioned below.

Per cent contribution of various components: The per cent contribution of each component to overall loss due to HS is presented in Table 3. The loss due to mortality of animals contributed the highest percentage loss in crossbred cattle (69.42%), indigenous cattle (63.15%) and buffaloes (70.40). Treatment constituted the second highest loss after mortality in each category of animal. Various studies had reported mortality loss due to HS ranging from as low as 58.9% to as high as 94% (Verma *et al.* 2004, Farooq *et al.* 2011, Singh *et al.* 2014a, b, Govindaraj *et al.* 2017). In our study area, mortality loss percentage was lower compared to reports from other states due to better vaccination

Table 2. Component wise per cent contribution to total economic loss due to HS

	Percentage (%) of total Loss (component-wise)				
	Milk yield loss	Treatment cost	Extra labour charges	Mortality loss	Misc.
Cross bred cattle	7.38	17.50	3.05	69.42	2.63
Indigenous cattle	4.20	25.30	2.44	63.15	4.89
Buffaloes	5.38	17.03	4.30	70.40	2.87

Table 3. Components of annual economic losses per animal due to HS of dairy animals in different agro-climatic zones of Punjab

	Agro-climatic Zones	Losses (component-wise) (₹) Milk yield loss	Treatment cost	Extra Labour charges	Mortality loss	Misc.	Total loss/ animal/ year (₹)
Crossbred cattle	I	503.5	850.2	134.8	5298.6	117.0	6904.1
	II	260.2	1444.1	260.8	2547.1	229.0	4741.4
	III	550.6	967.1	160.7	2747.7	135.7	4561.7
	IV	237.0	1145.2	233.6	3991.1	202.3	5809.2
	V	647.0	1010.1	160.6	5281.6	138.8	7238.0
	VI	372.5	673.4	111.1	4291.6	94.3	5542.8
	Mean±S.E.	428.5±67.4	1015.0±107.5	176.9±23.7	4026.3±486.1	152.8±21.2	5799.6±447.5
Indigenous cattle	I	81.8	524.4	52.6	1552.5	104.9	2316.3
	II	59.8	305.4	31.2	1757.3	61.0	2214.8
	III	93.7	701.2	73.3	1936.6	140.2	2945.1
	IV	32.3	179.4	18.2	1288.0	35.8	1553.7
	V	232.7	1099.8	97.6	2068.0	203.3	3701.5
	VI	72.225	636.9	60.6	0	120.7	890.4
	Mean±S.E.	95.4±28.8	574.5±132.5	55.6±11.7	1433.7±308.3	111.0±24.2	2270.3±405.2
Buffaloes	I	456.1	1436.0	363.0	5396.8	244.4	7896.3
	II	247.0	794.9	201.3	4816.4	135.4	6194.9
	III	497.2	1407.5	365.7	6962.6	242.3	9475.4
	IV	236.5	991.9	227.6	3305.4	152.1	4913.6
	V	575.3	1723.9	443.0	5948.3	295.4	8985.5
	VI	334.1	1071.8	275.0	4260.3	183.6	6124.8
	Mean±S.E.	391.0±56.9	1237.7±140.1	312.56±38.0	5115.0±525.4	208.9±25.2	7265.1±735.3

Table 4. Cost benefit analysis of control of Hemorrhagic septicemia in Punjab State

Category	Overall loss (₹/animal/yr) A	Vaccine effectiveness (%) B	Vaccine coverage (%) C	Total benefit of vaccination per year $D = A \times B \times C / 10^4$	Benefit cost ratio D/1000#
Crossbred Cattle	$5799.6^{b}\pm447.5$	95.33	94	5196.98	5.19
Indigenous cattle	$2270.3^{a}\pm405.2$	96.09	94	2050.63	2.05
Buffalo	$7265.1^{b}\pm735.3$	93.73	94	6400.98	6.4
Overall	5111.64±1482.32	94.55	94	4543.07	4.54

Different lowercase superscripts (a,b,c) indicate significant (P<0.05) difference. #₹1000 is estimated cost of various control measures.

coverage and also due to awareness of farmers about the dreadful nature of disease.

Loss of milk yield: The highest mean value of milk yield loss per animal per year across the species was highest in cross bred animals (₹ 428.46±67.42), followed by buffaloes (₹ 391.02±56.95) and indigenous cattle (₹ 95.42±28.77) as presented in Table 3. The average duration of illness in crossbred cattle, indigenous cattle and buffaloes was 7, 3 and 9 days respectively, with a corresponding average milk yield of 18, 10 and 8 litres of milk respectively. During the disease period, it was assumed that milk yield drastically reduced (up to 80% in cattle and 70% in buffaloes). Since milk loss was considered only during the illness period, hence its impact was higher in high yielder crossbred animals than indigenous animals. However, in case of buffaloes, the impact on milk reduction was more compared to cattle due to the higher incidence of HS in buffaloes. Similar findings were reported by Govindaraj *et al.* (2017) that higher milk losses were from cross bred animals due to high milk yield followed by buffaloes and indigenous cattle and estimated the mean milk loss per animal to be $2, $11 and $50 in indigenous cattle, water buffaloes, and crossbred cattle, respectively. Pal *et al.* (2017) reported that the monetary loss due to milk loss due to HS in Haryana was ₹ 8.18 crores, in which buffaloes contributed maximum (₹ 6.47 crore), followed by cross bred cows (₹ 1.59 crore) and indigenous cattle (₹ 0.12 crore).

Treatment cost: Total mean value of treatment cost per animal per year was maximum in buffaloes (₹ 1,237.7± 140.06), followed by crossbred cattle (₹ 1,015.0±107.52) and indigenous cattle (₹ 574.52±132.53). The treatment cost varied as per zone and category of animals due to the variation in the number of days of illness, prevalence rate, treatment charges and recovery level. Govindaraj *et al.* (2017) estimated the treatment expenses incurred among the bovines due to HS per animal was $24 which was almost similar to our estimated values. Singh *et al.* (2014b) reported that among the morbidity losses, the highest loss was treatment cost, as they didn't consider the replacement values of animal losses due to mortality of HS affected animal. In Haryana state, treatment cost due to HS in buffalo, cross bred and indigenous cattle was estimated to be ₹ 24.32, 9.39 and 2.21 crores, respectively (Pal *et al.* 2017).

Extra labour engagement cost: The cost incurred on additional labour to nurse the infected animal during the disease condition varied across the different agro-climatic zones of Punjab and different categories of animals (Table 3). The mean total loss per animal per year due to engagement of extra labour was highest in buffalo (₹ 312.56±37.99), followed by crossbred (₹ 176.93±23.72) and indigenous cattle (₹ 55.59±11.70). The differences in additional labour cost incurred in the surveyed zones were due to differences in duration of illness, recovery period, variation in wage rates and proportion of different category of animals owned by the farmer. Our findings concurred with Govindaraj *et al*. (2017), who estimated the extra labour expenses incurred per animal/outbreak as $7. The total loss incurred by engagement of extra labour for nursing HS affected animals in Haryana state was ₹ 11.63 crores, with buffaloes contributing maximum (₹ 10.13 crores) (Pal *et al.* 2017).

Loss due to mortality of animals: The average mortality loss in buffaloes was ₹ 5,115.0±525.40, followed by crossbred (₹ 4,026.3±486.10) and indigenous cattle (₹ 1,433.7±308.26). The variation in mortality loss among different categories of animals depends on several factors like age and sex of animal (Khan *et al.* 2006). We observed very few cases affecting male animals. Mortality among the animals was higher in buffaloes and crossbred animals (especially their young ones) as reported previously by several researchers (Ahmed 1996, De Alwis 1999 and Farooq *et al.* 2011). Loss due to mortality of animals is very important loss, since farmers have to replace the dead animals with a new batch of animals. HS caused an overall loss of ₹ 592.40 crores to Haryana State (Pal *et al.* 2017). The reported estimated loss due to HS induced mortality per annum in India ranged from ₹ 100 million (Tiwari *et al.* 2013) to as high as ₹ 225 million (Singh *et al.* 2008).

Miscellaneous cost: The total mean value of miscellaneous charges per animal per year in cross bred cattle, indigenous cattle and buffaloes was ₹ 152.84±21.17, ₹ 111.02±24.25 and ₹ 208.88±25.24 respectively. Differences in miscellaneous cost among different categories were due to differences in travelling charges to carry affected animals for treatment, disposal of dead carcass charges etc.

Total economic losses of dairy animals due to HS in different agro-climatic zones: The overall mean economic losses per affected animal per year due to HS was 5,111.6±1482.3 (Table 4). The mean economic losses per animal per year in crossbred cattle, indigenous cattle and buffaloes were ₹ 5,799.6±447.5, ₹ 2,270.3±405.2 and ₹ 7,265.1±735.3, respectively. The overall economic loss varied significantly with respect to category of animals ($P<0.05$) but not with respect to different agro-climatic zones. Maximum losses were skewed towards buffaloes, followed by cross bred and indigenous cattle. Our results concurred with those of Singh *et al*. (2014a), who recorded highest loss due to HS in buffaloes (₹ 4,262.57), followed by crossbred cattle (₹ 2,355.78) and ND cattle (₹ 3,228.52). Contrarily, Singh *et al*. (2014b) estimated the total economic loss per infected animal due to HS as ₹ 6,816 in case of cattle and ₹ 10,901 in buffalo. Recently Govindaraj *et al*. (2017) in Karnataka state contradicts our study that the average loss per animal due to mortality was $275 (₹ 17,875), $284 (₹ 18,480), and $415 (₹ 26,975), in case of indigenous cattle, water buffaloes, and crossbred cattle, respectively. This may be due to higher prevalence and case fatality rate of HS in the present study. Secondly, we considered loss of milk production only during the disease condition.

The economic loss per animal per year between different agro-climatic zones was highest in Zone VI (₹ 6,641.7± 2692.0) and lowest in Zone IV (₹ 4,092.2±2243.5). The Zone IV (Flood plain region) areas were lying towards the border side and these farmers lack proper awareness about this disease, harbor several myths towards vaccinating their farm animals and also may be due to poor coverage of vaccination.

The benefit cost analysis of intervention of control measures (including effective vaccination, biosafety measures taken at farm level and segregation of affected animals) revealed higher benefits cost ratio in case of buffaloes. The BCR calculated after mass vaccination (94% coverage) of HS in the state (DAHD, Punjab 2016) in different categories of animals is 2.05, 5.19 and 6.4 times for indigenous cattle, crossbred cattle and buffaloes under their different incidence scenario (Malik and Verma 2018). Different control measures provided at the farm was assumed to cost ₹ 1,000 for each animal annually for estimation of BC ratio of HS in dairy animals. In Punjab, the overall BCA of 4.54 irrespective of species indicated that the benefits outweigh the cost incurred for vaccination under all the incidence scenarios. It indicates that net benefits forgone from the non-affected animals could be higher once the intervention of effective HS control measures (vaccination and proper biosafety measures, etc.) at farm.

The projected loss due to HS affected animals in the Punjab was calculated on the basis of incidence level during the survey period of 2016–17 and was estimated to about ₹ 211.37 crores per year. Thus, these findings clearly indicated that if this dreadful disease is controlled at early stages through the intervention of effective mass vaccination these losses incurred can be avoided and provide a profitable enterprise of dairy business to the farmers and improve the livestock economy of the state while reducing these losses. Some critical measures to counter this disease include the availability of broadly protection and long lasting effect of vaccines, to unravel the mysteries of the pathogen and its virulence factors, pathogenesis and determinants of protective immunity as well as diversity among strains of *P. multocida*, emergency veterinary service during the outbreak and proper cold storage of vaccines at field level. Avoid use of contaminated water of ponds during disease outbreak (Abdullah *et al*. 2013). Using single needle for vaccination, without sterilization between animals, during outbreak of the disease (Jindal *et al.* 2002). Ensuring strict biosafety measures and hygienic sanitary conditions, adequate early disease detection and good availability of veterinary and extension services will help in control of this disease.

It may be concluded that HS in dairy animals strongly impacts the economics of dairy enterprise especially those rearing buffaloes and young ones as they are more susceptible to HS. Adoption of proper control measures and to overcome critical gaps like intervention of effective mass vaccination at farm level not only reduces prevalence of the disease but increases profitability of dairy sector in the state.

ACKNOWLEDGEMENTS

The authors thankfully acknowledge the funds and support from GADVASU, Ludhiana and the cooperation from dairy farmers of Punjab to conduct this study.

REFERENCES

Abdullah F J J, Khaleel M M, Adamu L, Osman A Y, Haron A, Saad M Z and Omar A. 2013. Polymerase chainreaction detection of *Pasteurella multocida* type B: 2 in mice infected with contaminated river water. *American Journal of Animal and Veterinary Sciences* **8**: 146–51.

Ahmed S. 1996. Status of some bacterial diseases of animals in Bangladesh. *Asian Livestock Journal* **21**: 112–14

DAHD. 2016. Department of animal husbandry and dairying Punjab 2016–17. Annual Report.

De Alwis M C L. 1990. *Haemorrhagic Septicaemia.* ACIAR Monograph No. 57, p. 33.

De Alwis M C L. 1992. HaemorrhagicSepticaemia " a general review. *British Veterinary Journal* **148**: 99–12.

De Alwis M C L. 1999. Haemorrhagic Septicaemia. ACIAR Monograph No. 57. Australian Centre for International Agricultural Research, Canberra, Australia.

Dua K. 2003. *Comparative disease susceptibility of cattle and buffalo in Punjab* (*India*). Proceedings of 10th International Symposium on Veterinary Epidemiology and Economics, Vina del Mar, Chile, South America.

Dutta J, Rathore B S, Mullik S G, Singh R and Sharma G C. 1990. Epidemiological studies and occurrence of Haemorrhagic Septicaemia in India. *Indian Veterinary Journal* **67**: 893–99.

FAO. 1995. Production Yearbook 1995, FAO, Statistics Division.

Farooq U, Zaka S and Khan M. 2011. Sero-surveillance of Hemorrhagic septicemia in cattle and buffaloes in district Dera-Ghazi-Khan, Punjab, Pakistan. *Pakistan Veterinary Journal* **31**(3): 254–56.

Gajendragad M R and Uma S. 2012. Status of Haemorrhagic Septicaemia in India. PDADMAS Technical Bulletin No.11. Project Directorate on Animal Disease Monitoring and Surveillance, Bengaluru, India.

Govindaraj G, Ganeshkumar B, Nethrayini K, Shalini, R., Balamurugan V, Pattnaik B and Rahman H. 2017. Farm community impacts of foot-and-mouth disease outbreaks in cattle and buffaloes in Karnataka state, India. *Transboundary and Emerging Disease* **64**: 849–60.

Jindal N, Kumar S, Narang G, Chaturvedi G C, Tomer P and Garg D N. 2002. Some epidemiological observations on haemorrhagic septicaemia in buffaloes and cattle in Haryana state of India. *Buffalo Journal* **2**: 273–80.

Khan A, Saddique U and Ahmad R. 2006. Sero-surveillance of Hemorrhagic septicemia in cattle and buffaloes in district Malakand, NWFP, Pakistan. *Journal of Agricultural and Biological Science* **1**(4): 11–14.

Mahi G S and Kingra P K. 2013. Agroclimatic regions of Punjab, pp. 236–240. *Fundamentals of Agrometrology*. Kalyani Publishers.

Malik M H and Verma H K. 2018. Epidemiological aspects and the major constraints in controlling Haemorrhagic Septicemia in dairy animals of Punjab. *Indian Journal of Animal Sciences* **88**(10): 1112–17.

Pal R, Kumar S, Bardhan D, Anandasekaran G, Verma M R, Singh G, Chilambarasan M and Singh R K. 2017. Estimation of Economic losses due to Haemorrhagicsepticaemia in Haryana, *International Archive of Applied Sciences and Technology* **8**: 09–13.

Singh B, Shiv Prasad V and Singh M R. 2014a. Estimation of economic losses due to Hemorrhagic Septicaemia in cattle and Buffaloes in India. *Agricultural Economics Research Review* **27**: 271–79.

Singh D, Kumar S, Singh B and Bardhan D. 2014b. Economic losses due to important diseases of bovines in central India. *Veterinary World* **7**(8): 579–85.

Singh B and Prasad S. 2008. Economic evaluation of important cattle diseases in India. *Indian Veterinary Journal* **85**(11): 1207–10.

Singh V P, Kumar A A, Srivastava S K and Rathore B S. 1996. Significance of HS in Asia: India. Report of International Workshop on Diagnosis and Control of HS. *Indonesian Department of Agriculture, Bali, Indonesia*.**34**: 135–40.

Tiwari R, Sharma M C, Mishra K K, Singh B P. 2013. Economic impacts of infectious diseases of livestock. *Indian Journal of Animal Sciences* **83**: 316–20.

Venkataramanan R, Bandyopadhyay S K and Oberoi M S. 2005. Present status and strategies for the control of transboundary and other economically important animal diseases in India: A review. *Indian Journal of Animal Sciences* **75**: 456–64.

Verma R and Jaiswal T N. 1998. Haemorrhagic septicaemia vaccines. *Vaccine* **16**: 1184–92.

Verma S, Mahajan N K and Malik G. 2004. An epidemiological study on bovine HS in Haryana. *Indian Journal of Animal Research* **38**(1): 14–19.