Estimation of economic losses due to classical swine fever in pigs in Mizoram

J K CHAUDHARY[1], N SHYAMSANA SINGH[2], T C TOLENKHOMBA[3], S K BEHERA[4] and
VANLALCHHUANGA[5]

Central Agricultural University, Selesih, Aizawl, Mizoram 796 014 India

ABSTRACT

Classical swine fever (CSF) also known as 'hog cholera' is an important viral disease of pigs in India with serious economic concern due to morbidity and mortality, and affects a vast section of the pig population in India. In present study, a structured sampling design was adopted, which covered the major regions of the Mizoram, to ascertain the economic losses due to CSF in pigs. Available estimates of the economic losses of Mizoram due to CSF are based on single values of various epidemiological and economic parameters. Overall annual morbidity, mortality and case fatality rates of CSF in Mizoram were 8.35, 5.07 and 60.70% respectively. The expected annual economic loss due to CSF in pigs in Mizoram was ₹ 16,69,34,465. Losses due to mortalities contributed the most to the total economic loss caused by CSF in pigs, followed by loss in body weight. This study revealed significant losses due to the incidence of CSF in pigs of Mizoram.

Key words: Classical swine fever, Economic losses, Logistic regression, Mizoram, Morbidity rate, Mortality rate

Classical swine fever (CSF) or hog cholera is a highly contagious pig disease that causes serious economic losses directly due to mortality, retardation of growth, reproductive problems of affected pigs and indirectly by bringing restrictions on exports of pork and pork products from the affected countries (Sarma *et al.* 2008). The loss accounted for more than ₹ 2 billion every year in a limited participatory epidemiological study conducted in three states (Asom, Mizoram, Nagaland) in the northeastern region of India, which is the hub of pig production in the country (Bett *et al.* 2012). High sero-prevalence of CSF in India (63.3%), suggest that the disease is endemic in the country (Nandi *et al.* 2011). Ahuja *et al.* (2014) reported the mean prevalence of CSFV antibodies from Meghalaya (52.27%) and Manipur (38.49%). In earlier studies, the attempts were made to estimate economic losses due to CSF in India (Singh *et al.* 2016). The disease is enzootic in most of the pig producing states and particularly in the north eastern states of India. Improving the surveillance system for CSF and understanding the epidemiology of the disease are important not only to prevent the spread of the disease but also to evolve suitable strategy to control the disease. In this study, an attempt has been made to evaluate the economic losses using the sample survey data from Mizoram of India.

MATERIALS AND METHODS

Sampling design: Districts (8) of Mizoram were divided into two agro-climatic zones. By taking two agro-climatic zones as strata, two districts each from zone 1 and zone 2 were selected randomly. From each selected district, two blocks and from each selected block, two villages were selected by simple random sampling without replacement scheme. A total of 15 pig owners were selected from each village and cumulatively 240 pig owners constituted the ultimate sample from 16 villages and 8 blocks for the study. The sampling scheme followed in the present study was stratified three-stage random sampling (Chaudhary *et al.* 2013).

Data: Data were collected on the epidemiological and economic parameters of CSF using a questionnaire, supported by a disease identification checklist based on clinical symptoms and photographs. The researchers contacted the local Government Veterinary Officer in each of the administrative blocks where the survey was being carried out, to explain the objectives of the survey. The Veterinary Officer then nominated several farmers based on his or her information in the selected villages.

The questionnaire was divided into 5 sections. The first section asked for a description of the sample household and its characteristics. The second section covered the household's livestock holding and details of breedable animals (pig population). The third section dealt with the

Present address: [1]Assistant Professor (vetjitu@gmail.com), [2]Associate Professor and Head (nssagb@rediffmail.com), [3]Assistant Professor (drkhomba10@gmail.com), Department of Animal Breeding and Genetics; [4]Assistant Professor (drsuvendu.kumar@gmail.com), Department of Veterinary Medicine, College of Veterinary Science and Animal Husbandry. [5]Project Assistant (renthlei.lc2584@gmail.com).

details of live animals, their produce and sales (yield, uses, amount of produce or number of livestock sold, sale and livestock). The fourth section covered animal health management and details of any infected animals (species, sex, age). The fifth section dealt with the effect of the disease (mortality and morbidity) and contained questions on the market value of the animal, disease duration, loss of body weight, abortion, increased inter-farrowing period, the price of any new-born animals, and the costs of treatment and vaccination (Bardhan *et al.* 2017). The questionnaire was comprehensive and pre-tested. Data were collected between September 2017 and July 2018.

Statistical analysis: To measure the agreement between actual counts and expected counts assuming the null hypothesis, chi-square test and for identifying the factors responsible for disease occurrence, logistic regression analysis was used by using SPSS version 17 program.

Economic losses due to CSF in pigs: The total economic loss (T_L) due to CSF in pigs was worked out as sum of loss from mortality (A), losses due to reproductive failure in affected pigs (C), loss in body weight (D), cost of treatment of affected pigs (F) and opportunity costs (G).

$$\text{Total economic loss } (T_L) = A + C + D + F + G$$

Loss due to mortality: The losses (₹) due to mortality were estimated by multiplying the number of animals died in respective age groups with the price of the animals of the respective age group.

$$A = D_p P_p + D_y P_y + D_A P_A$$

where A, loss (₹) due to mortality; D_P, number of piglets died; Dy, number of young population died; D_A, number of adult population died; P_P, average market value (₹) of piglet; P_y, average market value (₹) of young animal; P_A, average market value (₹) of adult animal.

Losses due to reproductive failure

$$\text{Losses due reproductive failure } (C) = C_1 + C_2$$

Body weight loss due to increased inter-farrowing period: The loss due to reduction in body weight owing to less number of piglets born because of prolonged inter-farrowing period, caused due to delayed conception, was estimated with the following formula:

$$C_1 = \left(\frac{12}{K_1} - \frac{12}{K_1 + w} \right)(I-D)P_L N_K B_W P_W$$

where K_1, inter farrowing interval (months); w, delay in next conception (months); I, number of infected animals; D, number of died animals; P_L, proportion of sick animals in lactation; N_K, average number of live piglets per litter; B_W, average birth weight of a piglet (kg); P_W, price of live weight per kg (₹).

Body weight loss due to increased abortions: The loss (₹) due to reduction in body weight owing to increase in number of abortions was estimated with the following formula:

$$C_2 = \left(\frac{12}{K_1} - \frac{12}{K_1 + 5} \right)(I-D) \, P_L A N_K B_W P_W$$

where K_1, inter farrowing interval (months); w, delay in next conception (months); I, number of infected animals; D, number of died animals; P_L, proportion of sick animals in lactation; A, increased abortion rate; N_K, average number of live piglets per litter; B_W, average birth weight of a piglet (kg); P_W, price of live weight per kg (₹).

Direct loss in body weight: The direct body weight loss due to CSF was estimated by using the formula:

$$D = (I-D) \, (1-P_L) \, W_L W_A P_W$$

where I, number of infected animals; D, number of died animals; P_L, proportion of sick animals in lactation; W_L, proportion of body weight loss; W_A, average body weight of animal; P_W, price of live weight per kg (₹). Assuming the time for abortion as 2.5 months from conception and a delay of another 1.5 months in the next conception, the inter-farrowing period gets increased by 5 months in abortion cases.

Cost of treatment

Cost of treatment F = I T_C

where I, number of infected animal; T_C, treatment cost of an infected animal.

Opportunity costs (G): The opportunity cost comprising high cost of feeding, high cost of rearing due to longer rearing time, treatment cost, transport cost, extra labourers engaged for nursing sick animals, and disinfection of shed etc., were difficult to quantify due to lack of record, and were thus assumed approximately as 20% (0.20) of the cost of animals and was estimated by the following formula:

$$F = (S_p P_p + S_y P_y + S_A P_A) \times 0.20$$

where F, opportunity cost (₹); S_P, number of piglets survived; Sy, number of young animal survived; S_A, number of adult animal survived; P_P, average market value (₹) of piglet; P_y, average market value (₹) of young animal; P_A, average market value (₹) of adult animal.

RESULTS AND DISCUSSION

The overall annual morbidity, mortality and case fatality rates due to classical swine fever in Mizoram was estimated from this sample as 8.35, 5.07 and 60.70% respectively. The incidence rate varied across age group and season. Among the three age groups, young animals had highest morbidity rates followed by piglets and adults. The chi-square analysis revealed that there was significant difference (P<0.01) among age groups of pigs. The mortality rate was also highest for young animals followed by piglets and adult animals. The mortality rates also differed significantly (P<0.01) among different age groups (Table 1).

Among the three seasons, the morbidity rate for classical swine fever was higher in rainy season followed by summer and winter season. The chi-square analysis revealed that there was significant difference (P<0.01) among different

Table 1. Overall and age wise morbidity and mortality rates due to CSF in Mizoram

Parameter	Piglet	Young	Adult	Overall morbidity rate (%)	Overall mortality rate (%)	Case fatality rate (%)
	Number (%)	Number (%)	Number (%)			
			201 (8.35)	122 (5.07)	60.70	
Morbidity rate	117 (7.40)	72 (14.20)	12 (3.77)	$\chi2_{cal}$=33.23**		
Mortality rate	71 (4.49)	45 (8.88)	6 (1.89)	$\chi2_{cal}$=23.05**		
Total	1581	507	318	Population at risk=2406		

*Significantly different at P<0.05; **Significantly different at P<0.01; values in bracket indicate percentage.

seasons. The mortality rate was also higher in rainy season followed by summer and winter season. The mortality rates also differed significantly (P<0.01) among different seasons (Table 2).

The logistic regression analysis with respect of classical swine fever revealed significant (P<0.01) difference in morbidity and mortality rate. The logistic regression analysis revealed that young animal and male animal were at higher risk of morbidity (Table 3), and young animal and female animal were at higher risk of mortality. The analysis showed that mortality was more in rainy season than summer and winter season (Table 4).

Nandi *et al.* (2011) also reported that 63.3% of the samples collected from 12 states in India had CSFV antibodies while 76.7% of the samples collected from 13 states had CSFV antigens. The case fatality rates obtained from this study approximate those published by Kumar *et al.* (2007) but the incidence estimates vary because they

measure different but related events. Incidence estimates published by Kumar *et al.* (2007) represent the number of animals affected in the CSF outbreaks studied while those obtained from this study represent the rate at which villages are affected by CSF outbreaks over a period of one year. All these findings show that young pigs suffer heavier mortalities compared to older animals.

Total economic loss due to CSF in Mizoram was ₹ 16,69,34,465. Out of the total loss, mortality accounted for 57.17%, while morbidity accounted for 42.83%. Total loss due to reduction in body weight accounted for 30.56%, comprising direct loss of 29.13% due to reduction in body weight, besides loss of 1.18% due to increase inter-farrowing period and loss of 0.26% due to abortions. Treatment and opportunity cost accounted for 4.91% and, 7.36% respectively (Tables 5, 6).

The morbidity loss emerged as the major contributor to the total loss due to CSF in pigs as per the data recorded by Government of India but mortality loss accounted for major share of total loss due to the same disease when economic loss was calculated as per the data obtained from sample survey study. Our results support earlier reports on CSF outbreaks, which have documented high morbidity and mortality rate as compared to Government of India reports. Singh *et al.* (2016) reported that economic losses due to CSF in pigs were 74.07% due to mortality and 25.93% due to morbidity, which was similar to our findings.

The present study was planned to generate information about the economic losses caused by classical swine fever

Table 2. Season wise morbidity rates due to CSF in Mizoram

Parameter	Summer		Winter		Rainy		χ^2_{cal}
	Cases	%	Cases	%	Cases	%	
Morbidity rate	79	3.28	25	1.04	97	4.03	62.13**
Mortality rate	52	2.16	11	0.46	59	2.45	24.04**
Total number available			2406				

Table 3. Logistic regression analysis of morbidity rates due to CSF

Factor	B	SE	Wald	df	Sig.	OR
Age			359.048	2	.000	
Piglet	−3.492	.249	197.373	1	.000	.030
Young	.634	.310	4.180	1	.041	1.885
Adult	Ref.	-	-	-	-	1
Male	.514	.199	6.679	1	.010	1.672
Female	Ref.	-	-	-	-	1
Season			.248	2	.883	
Summer	−.129	.269	.232	1	.630	.879
Winter	−.074	.226	.106	1	.744	.929
Rainy	Ref.	-	-	-	-	1
Constant	1.178	.270	19.036	1	.000	3.247

Nagelkerke R Square, 0.604; OR, odds ratio; Ref, Reference category =1

Table 4. Logistic regression analysis of mortality rates due to CSF

Factor	B	SE	Wald	df	Sig.	OR
Age			65.624	2	.000	
Piglet	−.548	.532	1.063	1	.303	.578
Young	3.114	.650	22.930	1	.000	22.509
Adult	Ref.	-	-	-	-	1
Male	−.721	.255	7.972	1	.005	.486
Female	Ref.	-	-	-	-	1
Season			16.908	2	.000	
Summer	−.818	.313	6.822	1	.009	.441
Winter	−1.360	.368	13.646	1	.000	.257
Rainy	Ref.	-	-	-	-	1
Constant	−.227	.530	.183	1	.669	.797

Nagelkerke R Square, 0.331; OR, odds ratio; Ref, Reference category =1

Table 5. Parameters and estimates of CSF in pigs

Parameter	Notation	Estimates	Source
Number of infected animals	I	20,477	BAHS (2017)
Number of died animals	D	12,433	BAHS (2017)
Proportion of animals in lactation (%)	P_L	22.22	Probable value
Increased abortion rate (%)	A	0.10	Probable value
Farrowing interval (months)	K_1	5.0	Probable value
Delay in next conception (months)	W	1.5	Probable value
Price of live weight per kg (₹)	P_w	250	Probable value
Number of live piglets per farrowing	N_k	8	Probable value
Birth weight of piglet (kg)	B_w	1.0	Probable value
Average body weight (kg)	W_A	155	Probable value
Proportion of body weight lost (%)	W_L	20	Singh (2016)
Average price (₹) of piglets	P_P	5500	Probable value
Average price (₹) of young pigs	P_Y	10,000	Probable value
Average price (₹) of adults pigs	P_A	16,000	Probable value
Treatment cost of an infected animal (₹)	T_C	400	Probable value

Basic Animal Husbandry and Fisheries Statistics (BAHS) and 19th Livestock Census (2017). Probable value is the average value obtained from sample survey data.

Table 6. Annual economic loss (₹) due to CSF in pigs in Mizoram

Component of economic loss	Value (₹)	% loss
Mortality loss	9,54,40,000	57.17
Morbidity loss		
Direct body weight loss	4,86,25,980	29.13
Losses due to reproductive failure		
Body weight loss due to increased farrowing interval	19,66,115	1.18
Body weight loss due to increased abortions	4,28,970	0.26
Total loss due to reproductive failure	23,95,085	1.43
Cost of treatment	81,90,800	4.91
Opportunity cost	1,22,82,600	7.36
Total morbidity loss	7,14,94,465	42.83
Total loss due to CSF	16,69,34,465	

(CSF) in Mizoram state of India. The analysis involved determining the incidence, mortality and morbidity rates of CSF across Mizoram, using a survey tools. The expected annual economic loss due to CSF in pigs in Mizoram was ₹ 16,69,34,465. Losses due to mortalities contributed the most to the total economic loss caused by CSF in pigs, followed by loss in body weight. The estimates of economic losses due to CSF in pigs in Mizoram revealed a significant loss due to mortality and morbidity of the animals. Thus, CSF should be considered an important disease from a policy perspective when it comes to mitigating losses due to disease in livestock. This calls for investments in research on CSF and the implementation of vaccination schedule, identification and recording systems, public awareness, hygiene and bio-security, and movement control as preventative measures.

ACKNOWLEDGEMENTS

REFERENCES

Ahuja A, Mukharjee P, Bhattacharjee U, Chakraborty A K, Karam A, Ghatak S, Puro K, Das S, Shakuntala I, Srivastava N and Sen A. 2014. Classical swine fever virus infection in India: seroprevalence study from north-eastern states of India. *Indian Journal of Hill Farming* **27**(2): 1–3.

BAHS 2017. 18th Livestock Census. Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture.

Bardhan D, Kumar S, Anandsekaran G, Chaudhury J K, Meraj M, Singh R K, Verma M R, Kumar D N, Kumar P T, Lone S A, Mishra V, Mohanty B S, Korade N and De U K. 2017. The economic impact of *peste des petits* ruminants in India. *Scientific and Technical Review of the Office International des Epizooties* **36**(1): 245–63.

Bett B, Deka R, Padmakumar V and Rajasekhar M. 2012. Classical swine fever in northeast India: Prevention and control measures. ILRI Policy Brief 7. ILRI, Nairobi, Kenya.

Chaudhary J K, Singh B, Prasad S and Verma M R. 2013. Analysis of morbidity and mortality rates in bovine in Himachal Pradesh. *Veterinary World* **6**: 614–19.

Deka R, Thorpe W, Kumar A and Lapar M A. 2008. Assam's pig sub-sector: current status, constraint and opportunities. International Livestock Research Institute (ILRI), New Delhi.

Nandi S, Muthuchelvan D, Ahuja A, Bisht S, Chander V, Pandey A B and Singh R K. 2011. Prevalence of classical swine fever virus in India: a 6-year study (2004–10). *Transboundary and Emerging Diseases* **58**: 461–63.

Sarma D, Krishna L and Mishri J. 2008. Classical swine fever in pigs and its status in India: A review. *Indian Journal of Animal Sciences* **78**(12): 1311–17.

Sarma D K, Mishra N, Rajukumar K, Sarma S and Singh N K. 2008a. Isolation and characterization of classical swine fever virus from pigs in Assam. *Indian Journal of Animal Sciences* **78**: 37–39.

Singh B, Bardhan D, Verma M R, Prasad S, Sinha D K and Sharma V B. 2016. Incidence of classical swine fever (CSF) in pigs in India and its economic valuation with a simple mathematical model. *Animal Science Reporter* **10**(1): 3–8.

SPSS/PC. 2016. Windows for version 17.0., Release on December 2016. Microsoft Corporation.