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Causes of loss of Sonali chickens on smallholder households in Bangladesh

P.K. Biswas [a,*], G.M.N. Uddin [a], H. Barua [a], K. Roy [b], D. Biswas [c], A. Ahad [a], N.C. Debnath [d]

[a] *Department of Microbiology, Chittagong Government Veterinary College, Pahartali, Chittagong-4202, Bangladesh*
[b] *Department of Pathology and Parasitology, Chittagong Government Veterinary College, Pahartali, Chittagong-4202, Bangladesh*
[c] *Department of Medicine and Surgery, Chittagong Government Veterinary College, Pahartali, Chittagong-4202, Bangladesh*
[d] *Chittagong Government Veterinary College, Pahartali, Chittagong-4202, Bangladesh*

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Abstract

In a 1-year-long prospective longitudinal study, we determined the causes of loss of 'Sonali' (♂ Rhode Island Red × ♀ Fayoumi) chickens at key-rearers' households of the smallholder livestock development project-2 (SLDP-2) area in Bangladesh. A key rearer is a smallholder of chickens in the 'village poultry-production chain' (undertaken by SLDP-2 under the financial assistance of the DANIDA) who rears at least five Sonali and some 'Deshi' (non-descriptive and indigenous) chickens in their homesteads based on semi-scavenging system. The aim of this program is to ameliorate poverty, especially among women. Two co-ordination centers (set at the Potuakhali and Noakhali districts) supervised the development activities. We selected two upazilas (lower administration units) randomly from each of the two districts and in every selected upazila, we selected at random 125 key-rearer households. Incidence rates of loss of Sonali chickens from disease, predation, selling and slaughtering were 0.025, 0.023, 0.081 and 0.039 per bird-month at risk, respectively. The major

Abbreviations: IBD, infectious bursal disease; IBDV, infections bursal disease virus; IRR, incidence rate ratio; DANIDA, The Danish International Development Agency; DLS, Department of Livestock Services; FP, fowl pox; NGO, non-governmental organization; ND, Newcastle disease; NDV, Newcastle disease virus; PLDP, participatory livestock development project; SLDP-2, smallholder livestock development project-2; UPHW, upazila poultry health worker

* Corresponding author. Tel.: +88 31 659093x110/126; fax: +88 31 659620.
E-mail address: biswaspk2000@yahoo.com (P.K. Biswas).

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predators of Sonali chickens in the study area were foxes, a kind of wild cat (*Felis chaus*), mongooses and human thieves. Colibacillosis (both single and mixed infections) had a contributory role in the death of 28% of dead Sonali birds collected for diagnosis; salmonellosis, Newcastle disease and internal parasites contributed to the next highest (14, 11and 10%) proportional mortalities.

Keywords: Causes; Mortality; Semi-scavenging Sonali chickens

1. Introduction

Bangladesh is developing (Permin et al., 2000) a 'village poultry-production chain' by interlinking different resource-poor people, particularly the woman (Ahamed, 2002) through the smallholder livestock development project-2 (SLDP-2). The program runs in 26 upazilas (an upazila is a lower administrative unit of Bangladesh) of five southern districts with the help of 12 NGOs (non-governmental organizations). The NGOs are the direct credit suppliers to the beneficiaries and only one NGO is assigned to an upazila. In any one upazila, the intention is to have numerous microenterprizes – 4000 key rearers, 40 chick rearers, 20 model breeders, 100 poultry workers, 10 feed sellers and 10 egg collectors – all interlinked in a cooperative fashion. By definition, a key rearer is a beneficiary who rears at least five Sonali and some Deshi (indigenous and non-descriptive) chickens in their homesteads under a semi-scavenging system (Fattah, 1999); there are now 104,000 key rearers. The cross-bred Sonali birds are intended to make the system sustainable and lucrative.

The Sonali have better production records (50–60% hen-day egg production with feed-conversion efficiency of 4.3% and lower age for first egg production with 50% in production by 179 days) and higher disease resistance compared to Rhode Island Red and Fayoumi breeds (Haque et al., 1999; Miah et al., 2002). However, Sonali chickens reared in more-northern districts were more affected by Newcastle disease (ND) than Deshi birds (Biswas et al., 2005). There are no comparable data for Sonali chickens in the southern districts. In addition, the roles of predation, need-based selling and slaughtering involved in causing losses of Sonali chickens have never been assessed under the project. We described both disease and non-disease factors responsible for losses of Sonali chickens at the key beneficiaries' households in the SLDP-2 areas of Bangladesh.

2. Materials and methods

2.1. Study population and management of semi-scavenging Sonali birds

SLDP-2 has been operating its village poultry-production chain in 26 upazilas of five southern districts of Bangladesh. There are two regional co-ordination centers under the SLDP-2; one is based at Potuakhali district and the other at Noakhali to monitor developmental activities of 11 and 15 upazilas, respectively. There are several chicken-breeding farms established under the Department of Livestock Services (DLS) of

Bangladesh to supply day-old Sonali chicks to the chick rearers through the NGO (employed by the SLDP-2). The parent birds at breeding farms are vaccinated against Newcastle disease, infectious bursal disease (IBD) and fowl pox. A chick rearer is supplied with 300–400 Sonali chicks; these chicks are reared under an intensive system which is popularly known as 'Macha' system of rearing in which the rearing floor for the chicks is made up with bamboo sticks. In the chick-rearer households, the birds are reared up for 2 months and then only female birds are distributed to key rearers at the rate of at least five birds to each key rearer. The price of a 2-month-old Sonali bird to key rearers is negotiated by the NGO. In the chick-rearers' holdings the birds are vaccinated with the F strain of Newcastle disease virus (NDV) in their first week of age followed by booster vaccination at day 21. Also, chicks are vaccinated against IBD at 14–16 and 24–28 days.

In the key-rearers' households, the birds are reared under a semi-scavenging system. They are allowed to scavenge and forage in and around the homestead to collect feed on their own during the day (particularly in the morning) and they are supplied additional feed in the form of cereal grains, broken maize, oyster shell and fish meal separately in different chambers of a feeder (a 'cafeteria system' of feeding). By scavenging the birds can collect 40% of their feed requirement (Ali, 2002) and the rest needs to be supplemented. Only Sonali birds >2 months old are allowed to scavenge in the key rearers' homesteads and the birds are provided with both day and night shelters. At the beginning of rearing at key-rearers' households, the birds are vaccinated with 'Ranikhet (the popular name of Newcastle disease in the Indian sub-continent) Disease Vaccine' which is known as RDV (Mukteswar strain of NDV) and the same vaccination is repeated at 4–6-month intervals. The vaccines are produced and supplied by the DLS and the vaccination program is carried out by the beneficiaries known as 'poultry workers'.

2.2. Nature of the study, the study areas and calculation of the sample size

We did a 1-year-long prospective longitudinal study from September 2003 to August 2004 (inclusive) on Sonali chickens reared at key-rearers' households' in four upazilas. For each of the two district centers, two upazilas were selected randomly by lottery. The selected upazilas were Bauphol and Kolapara in Potuakhali district; Noakhali Sadar and Porshuram in Noakhali district. For the respective upazila, the list of all 4000 key rearers was collected from the relevant NGO: Resource Development Foundation (RDF), Stichting Land Ontwikkelingo Project Bangladesh (SLOPB), Noakhali Regional Development Society (NRDS), and Padakhep for Kolapara, Bauphol, Noakhali and Porshuram upazila, respectively. All the key rearers under these four upazilas were women and most of them had no other jobs except house keeping and poultry rearing. The list of key rearers in an upazila kept by the NGO was used as a sampling frame and by generating random numbers in a computer, 125 key rearers' Sonali flocks were selected in each upazila to follow up the birds for up to 1 year.

To estimate the frequencies of factors involved in loss and death of Sonali birds, we calculated minimum number of birds to be 512 based on the formula, $n = Z^2PQ/L^2$ (Permin and Hansen, 1998), where n = sample size, P = expected prevalence, $Q = 1 - P$, L = required precision. Because the prevalence was not known, we used 20% ($P = 0.20$), a precision of 5% ($L = 0.05$) and confidence level 95% (i.e. $Z = 2$). According

to the definition, a key rearer should rear at least five Sonali birds, so 125 key rearers should have implied ≥625 birds. The size of the study population was estimated based on the total number of birds recorded at the beginning and the end of 11 consecutive months. The incidence rates of bird losses as consequences of (or contribution by different factors) were estimated by using the number of birds found lost or dead during the 11 months as the numerator and the total number of bird-months at risk as denominator. Proportional mortalities were calculated by using the number of deaths contributed by a specific cause as numerator divided by the number of dead birds collected and examined as denominator during the 12 months. (Because so many dead birds were not collected for diagnostic examination, we were unable to calculate mortality rates.)

2.3. Collection of information related to non-disease factors involved in birds' losses

The losses due to predation, need-based selling and slaughtering for meat purposes were assessed by retrospective information provided by beneficiaries each month. To collect this information, in this study, four upazila poultry-health workers (UPHWs) were employed (one per upazila). Prior to sending the UPHWs to the upazilas, they had been trained how to gather these data from the beneficiaries and to collect organ samples from dead birds. They were also trained how to identify internal parasites seen in different organs particularly in the gastrointestinal tract. In addition, the UPHWs were assigned to gather disease and epidemiological supporting data. Each UPHW was provided with a data-collection book to write down that retrospective information at the beginning of a particular month by interviewing (predominantly) the owners of the flocks. The interview was done in Bengali (the only language of the study areas). Every UPHW was given a bicycle so that they could make visits at least thrice a week to the beneficiaries' houses to collect dead birds which had died after clinical illness. The beneficiaries cooperated with the investigation fully as a part of their agreement to the credit supplier and the program developer. In addition, the UPHW had a financial incentive at the rate of taka 30 (taka is the currency of Bangladesh; US$ 1 = 66.0 taka) for collecting each dead bird.

2.4. Collection of organ samples from dead chickens

The UPHWs collected organ samples: liver, spleen, heart, lungs, trachea and bursa Fabricii from dead birds. Each organ sample was placed separately in a polythene bag and all samples taken from a single dead bird were kept together in an identity-tagged polythene bag (the whole dead bird was not frozen due to lack of space). All samples collected from a particular upazila were kept frozen in a refrigerator placed at the respective upazila NGO office. These samples were transferred by the UPHWs themselves to the Department of Microbiology, Chittagong Government Veterinary College, Pahartali, Chittagong, Bangladesh, on a monthly basis for investigation.

2.5. Collection of additional disease data

Every field sample was accompanied by a form filled in by the UPHW with identification of the beneficiary, medication history, vaccination history, post-mortem

examination findings and tentative diagnoses made by the UPHW based on clinical history and/or on the findings of the UPHW's post-mortem examination.

2.6. Diagnosis of diseases in Sonali chickens

The diagnoses of important bacterial, viral and fungal diseases were made following the criteria in the OIE Manual (OIE, 2002) with modifications as needed considering unavoidable field conditions and limitations of laboratory resources. Thus, Newcastle disease was diagnosed by isolating the causative virus in the embryonated chicken eggs and the identification of the virus was done observing haemagglutination and then specific haemagglutination-inhibition properties. Fowl pox was diagnosed by the characteristic dermal lesions, particularly on the head regions; confirmation of this disease was made when prepared inocula from these dermal lesions produced pocks on chorio-allantoic membranes of embryonated chicken eggs. Using bursal homogenate as source of antigen for infectious bursal disease virus (IBDV), this virus was diagnosed by agar-gel precipitation applying reference serum (Bio check, Holland). Infectious bronchitis was identified by lesions in chicken embryos (e.g. curling and dwarfing) after inoculating tracheal materials into the allantoic sac. Salmonellosis, colibacillosis and aspergillosis cases were identified by conventional methods (OIE, 2002); fowl cholera was diagnosed by seeing characteristic bipolar bacteria (presumed *Pasteurella multocida*) microscopically in Giemsa-stained liver imprints. Marek's disease was tentatively diagnosed by neurologic changes as observed during ante- and post-mortem examinations. Lymphoid leukosis was identified on the basis of observation of enlarged organs and tumerous growth in some soft organs (particularly, liver and spleen). Visceral gout was recognized as swollen kidneys and urate deposits on the viscera and within the joints. Cachexis was based on any of these four conditions: absent or insufficient food particles in the crop and the gizzard, back-flow of bile into the proventriculus, pale liver and overall unthriftness of the carcass.

2.7. Procedure for parasitological examination

The birds collected by the UPHWs were examined post-mortem at the NGO office by the UPHWs themselves. A transverse incision cranial to the proventriculus was made and the whole gastrointestinal tract was removed caudally. Then a transverse incision was made cranial to the cloaca and the tract was removed completely and placed in a tray. The entire tract was opened longitudinally. The contents and the mucosal scrapings were washed with clean water carefully and passed through a sieve with an aperture $\leq$100 μm. The contents of the sieve were transferred to a clean Petri dish to collect the grossly found intestinal parasites. All of the collected parasites from a dead bird were preserved in 70% ethanol in a screw-cap vial and shifted to the Department of Parasitology, Chittagong Govt. Veterinary College, Pahartali, Chittagong, Bangladesh for final morphological identification of the parasites according to the FAO Animal Health Manual (Permin and Hansen, 1998). If there were $\geq$10 intestinal parasites like *Ascardia gali* without any concomitant bacterial or viral disease, parasitosis was considered to have contributed to the death of the bird.

2.8. Data analysis

All diseases and epidemiological data were entered into a spreadsheet program (Excel 2000, Microsoft Corporation) and transferred to STATA-7 (STATA Corporation) statistical software for data management and summary.

3. Results

3.1. Major causes of Sonali chickens losses in the smallholder households

An overview of the study population and number of birds found dead in the study period is shown in Table 1. During the 12 months of observation bird-months at risk were calculated for 11 months because the number of birds remaining in the beginning of the 13th month (September 2004) was not recorded (because this work was financed for an active surveillance of 12 months). However, overall, 17,118 birds were recorded at the beginning of 12 months and 15,472 bird-months at risk were observed in 11 months. The incidence rate of loss as a result of disease, predation, selling and slaughtering was 0.168 (0.162, 0.174) (i.e. 168 birds were lost per 1000 bird-months at risk). The cause-specific incidence rates of mortality as for disease, predation, selling and slaughter were 0.025 (0.023, 0.027), 0.023 (0.021, 0.025), 0.081 (0.077, 0.085) and 0.039 (0.036, 0.042), respectively. The major predators of the Sonali birds were foxes, wild cats, and mongooses (Table 2).

3.2. Demography of active beneficiaries

Not all of 125 beneficiaries in an upazila reared Sonali birds. Of the 125 beneficiaries in each upazila, 112, 124, 121 and 81 beneficiaries in Kolapara, Bauphol, Noakhali Sadar and

Table 1
The study population and major causes of loss of Sonali chickens on 600 smallholder households in Bangladesh

Period commencing	No. birds recorded on visit day	Estimated bird-months at risk	No. lost			
			Disease	Predator attacks	Sold out	Slaughter
September 2003	2491	2233.5	36	97	276	109
October 2003	1976	2063.5	42	36	92	48
November 2003	2151	1987.5	63	26	201	63
December 2003	1824	1687.5	42	65	196	72
January 2004	1551	1469.5	50	15	101	56
February 2004	1388	1279.5	29	66	106	76
March 2004	1171	1124.5	22	15	84	75
April 2004	1078	992	55	17	66	46
May 2004	906	916.5	14	9	67	16
June 2004	927	890.5	17	8	38	27
July 2004	854	827.5	18	2	21	16
August 2004	801	–	[5]	[13]	[27]	[15]
Total	17118	15472	388	356	1248	604

Number in the brackets not added to the total number.

Table 2
Numbers of Sonali chickens killed, by predator, in 600 smallholder households in Bangladesh (September 2003–August 2004)

Predator	No. killed	% Lost[a]
Crow	5	<1
Dog	7	<1
Eagle	7	<1
Fox	81	5
Human (theft)	33	2
Jackal	3	<1
Mongoose	36	2
Rat	7	<1
Wild cat	78	5
Unseen predator/others	112	7
Total	369	22

[a] Average population = (no. placed at the first month + no. recorded at the last month)/2 = 1646.

Porshuram respectively had Sonali birds at the beginning of this surveillance (Fig. 1). During the first month of observation, the median number of Sonali birds held by a key rearer was 6 (minimum 1; maximum 20). However, in three upazilas (Kolapara, Bauphol and Porshuram), in the last month of our study ≤43 beneficiaries retained Sonali birds (median per household 2; minimum 1; maximum 16).

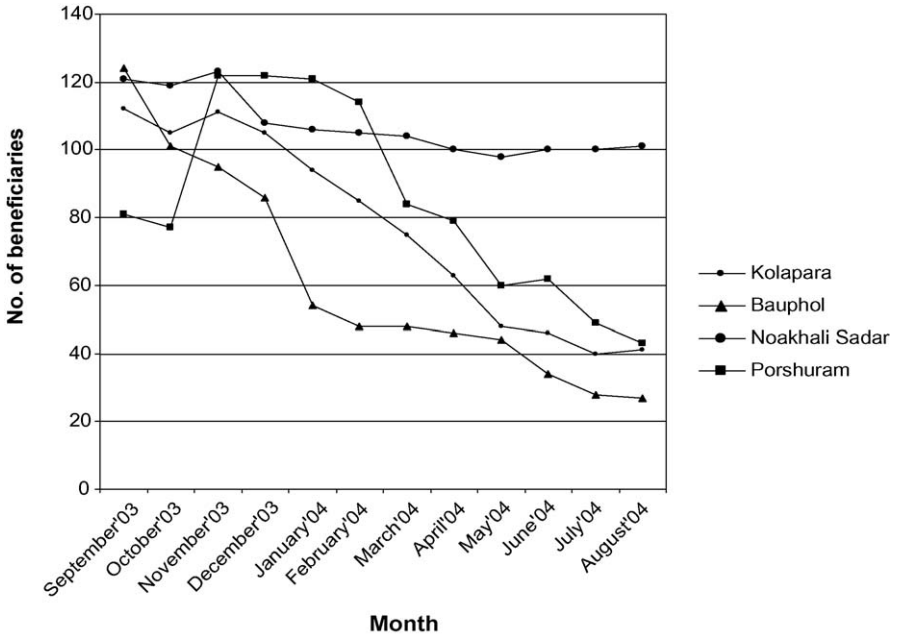

Fig. 1. Frequencies of active beneficiaries among 125 key rearers in each of four upazilas of Bangladesh, who were holding Sonali chickens from September 2003 to August 2004.

Table 3
Cause-specific proportional mortalities for agents contributing to deaths among Sonali chickens collected for post-mortem examination (600 smallholder households; Bangladesh; September 2003–August 2004)

Diagnosis (i.e. contributed cause)	Total birds	Proportional mortality (%)	Comment
Cachexia	7	5	Two also had parasitosis
Colibacillosis XX[a]	41	28	–
Fowl cholera (FC)	5	3	–
Fowl pox	9	6	–
Internal parasitic infections	15	10	Three also had other diseases
Newcastle disease	16	11	Five cases had other infections
Predation	8	5	Samples collected after predator attacks
Salmonellosis	21	14	Three also had FC
Undiagnosed	17	11	Includes decomposed carcasses
Various other diagnoses	10	7	Each was made <4 times
Total	149	100	

[a] Cachexia (1); FC (4); internal parasitic infection (2).

3.3. Proportional mortality of Sonali chickens contributed by endemic and epidemic diseases

During the 12-month observation there were 393 Sonali birds reported to have died from diseases, of which 149 birds (40% of those found dead) were investigated after having organ samples collected from them. Among the dead birds collected, 28% had a history of being treated with antibiotics and almost as many (27%) had been reported to have vaccinated against Newcastle disease. Overall, 83% of the dead birds were harboring (single or mixed) bacterial, viral or parasitic infections (Table 3).

4. Discussion

In the first month of observation, most beneficiaries had Sonali chickens (median number per household = 6). However, after a few months of initiating the small chicken-rearing enterprise, many beneficiaries in Bauphol, Kolapara and Porshuram had sold a large section of the birds. We speculate that this might be related to repaying loan installments to the credit suppliers.

It may be argued that the number of birds examined for contributing causes of death are not representative. It was a very difficult field situation where the study was conducted. Village people of Bangladesh sometimes slaughter diseased birds to consume the meat and the dead birds quickly decompose due to scarcity of preservation facilities. Even though the UPHWs visited frequently (at least three times a week) and they had monetary incentive for collecting the dead birds, they succeeded to collect only 40%. Despite all these limitations, we point out that there is little published information on the disease of backyard chickens raised anywhere in the developing world including Bangladesh.

Almost as many Sonali birds were lost to predation as to clinical disease. As far as we know, this study seems to be the first to unveil the roles of predators in killing poultry raised

in the semi-scavenging system in Bangladesh; however, there are reports in other parts of the world on predation in free-range poultry flocks (Baker and Macdonald, 2000; Heydon and Reynolds, 2000; Kusina et al., 2001; Moberly et al., 2004). Foxes are the main predators of free-range poultry flocks in Britain (Kruuk, 1972; Moberly et al., 2004; White et al., 2000). In Zimbabwe, among the predators, dogs, baboons and some nocturnal feral cats were important killers of village chickens (Kusina et al., 2001). The Sonali chickens studied in the smallholders' households were >2 months old—therefore, adult or nearly adult birds. Foxes killed birds in each upazila. One might dispute the accuracy of the information gathered from the beneficiaries relating to predators' attacks on birds at the smallholder households. In this regard, to collect the data, there were no other alternatives but to believe the information provided by the beneficiaries retrospectively as they were discouraged from giving unconfirmed information. And, this is the reason why a section of birds was categorized as lost due to unseen predators' attacks. The adult chickens in a semi-scavenging flock can sense the danger coming up from the presence of a predator and the sound is likely to alert their owners. Most importantly, Bangladesh is the most densely populated country in the world. The taking of a bird by a predator might also be witnessed by the owner's neighbours, who can give the information to the owner about the kind of a predator involved in that particular incidence.

We acknowledge that the presence of a pathogen in a dead bird cannot be considered the absolute cause of the death of the bird. Colibacillosis seemed to have a contributory role to mortality; the proportional mortality from the PLDP areas was 2.7% (Biswas et al., 2005). Salmonellosis appeared to be the predominant disease at the first 4 months of observation, is in agreement with Haider (2003) who investigated Sonali birds in some selected key rearers' flocks in the SLDP-2 areas. We called any infection caused by *Salmonella gallinarum* and/or *Salmonella pullorum*, 'salmonellosis'. The proportional mortality for salmonellosis for the PLDP areas was 5.4% (Biswas et al., 2005) and for Mirpur Central Poultry Farm was 3% (Huq, 2002), and for chickens raised in commercial flocks in Bangladesh was 13% (Talha et al., 2001). Salmonellosis is transmitted both vertically and horizontally and is difficult to prevent (Bolder et al., 2002). But, the risk can be reduced by supplying chicks from salmonellosis-free dams.

ND is apparently present in the study area. These sporadic incidences should alert relevant authorities that there are birds susceptible to ND despite our vaccination program. The ND virus can be transmitted from the local indigenous chickens or even from non-poultry, wild birds (Glaucia et al., 2003). In addition, we observed that FP was a major disease problem affecting even adult Sonali birds in the SLDP-2 areas. We strongly advocate introducing FP vaccination for the chickens under the SLDP-2 areas.

Comparatively few dead Sonali birds were harboring parasitic infections; in contrast, the proportion in the PLDP areas was 94% (Rahman et al., 2003). This suggests successes of the Helminth-control strategy adopted in the SLDP-2 areas.

When colibacillosis is associated with infectious bronchitis virus or *Mycoplasma gallisepticum* infection, the concomitant infections can cause mortality (Nakamura et al., 1992; Rodrigues et al., 2001).

The DANIDA-assisted SLDP-2 village poultry-production chain seems to be unsustainable; the key beneficiaries sold a large fraction of the birds. We speculate that the manner of supplying the credits and the corresponding loan recovery explains for such

failure. It has also been reported that some of the beneficiaries diverted their credits to other means of livelihood instead of continuing to rear Sonali hens (Riise et al., 2005). The smallholders must repay the monthly loan installments (to avoid accruing the debt) to the credit suppliers (the NGOs) even before the laying age of the Sonali birds is reached. Also, this sort of loan recovery by the NGOs renders the beneficiaries short of cash, which in turn has implications about purchasing of drugs, vaccines and feeds for the remaining birds. The solution of the problem might lie in making adjustment of the modalities of credit recovery. Alternately, the beneficiaries can be allowed to rear Deshi (non-descriptive)/indigenous chickens instead of the Sonali without the credit because credit is less needed for adapting simpler method (Riise et al., 2005).

5. Conclusion

In the SLDP-2 areas of Bangladesh, at the beginning of key rearers' units, the median number of Sonali chickens was 6 per household; at the end of a year, this number was only 3. Due to combined involvement of four factors (diseases, predation, selling and slaughtering), the loss of the chickens is 0.168 per bird-month at risk. The three major diseases of Sonali chickens are colibacillosis, salmonellosis and Newcastle disease; their three main predators are foxes, wild cats and mongooses.

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References

Ahamed, N., 2002. Components of Bangladesh semi-scavenging poultry model. In: Presented in the Workshop, People Fight Poverty with Poultry: Learning from the Bangladesh Experience, Workshop held in Dhaka, Bangladesh on October 20–24, 2002.

Ali, S., 2002. Study on the effect of feed supplementation to laying hen under the rural condition of Bangladesh. M.Sc. Thesis. The Royal Veterinary and Agricultural University, Dyrlaegevej 2, 1870. Frederiksbeurg, Denmark, 25 pp.

Baker, S.E., Macdonald, D.W., 2000. Foxes and foxhunting on farms in Wiltshire: a case study. J. Rural Stud. 16, 185–201.

Biswas, P.K., Biswas, D., Ahmed, S., Rahman, A., Debnath, N.C., 2005. A longitudinal study of the incidence of major endemic and epidemic diseases affecting semi-scavenging chickens reared under the Participatory Livestock Development Project areas in Bangladesh. Avian Pathol. 34 (4), 303–312.

Bolder, N.M., Janss, L.L.G., Putirulan, F.F., Wagenaar, J.A., 2002. Resistance of broiler outbred lines to infection with *Salmonella enteritidis*. Avian Pathol. 31, 581–587.

Fattah, K.A., 1999. Poultry as a tool on poverty eradication and promotion of gender equality. In: Dolberg, F., Petersen, P.H. (Eds.), Proceedings of a Workshop on Poultry as a Tool in Poverty Eradication and Promotion of Gender Equality. pp. 16–28.

Glaucia, D.K., King, D.J., Seal, B.S., Brown, C.C., 2003. Virulence of six heterogeneous-origin Newcastle disease virus isolates before and after sequential passages in domestic chickens. Avian Pathol. 32, 81–93.

Haider, G.M., 2003. Prevalence of enteric bacterial diseases in poultry of some selected poultry rearing units of SLDP-2 area: isolation, identification and pathology of the identified diseases. A Master of Science (MS) Thesis in Pathology. Department of Pathology, Bangladesh Agricultural University, Mymensingh, December, 102 pp.

Haque, Q.M.E., Chowdhury, S.A., Haque, M.E., Sil, B.K., 1999. Poultry research in Bangladesh: present status and its implication for future research. In: Dolberg, F., Petersen, P.H. (Eds.), Proceedings of a Workshop on Poultry as a Tool in Poverty Eradication and Promotion of Gender Equality. pp. 151–164.

Heydon, M.J., Reynolds, J.C., 2000. Fox (*Vulpes vulpes*) management in three contrasting regions of Britain, in relation to agricultural and sporting interests. J. Zool. (London) 251, 237–252.

Huq, M.R., 2002. Longitudinal study of the causes of mortality of chickens in parent stock flocks of the Department of Livestock Services (DLS) of Bangladesh with a special emphasis on *Escherichia coli* infection. M. Sc. Thesis. The Royal Veterinary and Agricultural University, Dyrlaegevej 2, 1870. Frederiksbeurg, Denmark, 66 pp.

Kruuk, H., 1972. Surplus killing by carnivores. J. Zool. (London) 166, 233–244.

Kusina, J., Kusina, N.T., Mhlanga, J., 2001. A survey on village chicken losses: causes and solutions as perceived by farmers. In: Alders, R.G., Spradbrow, P.B. (Eds.), Australian Centre for International Research (ACIAR) Proceedings No. 113 on SADC Planning Workshop on Newcastle Disease Control in Village Chickens. pp. 148–155.

Miah, M.S., Islam, M.A., Ali, M.A., 2002. Growth and egg production performance of exotic pure breeds and crossbreeds chicken. Bangladesh Veterinarian 19 (1), 43–47.

Moberly, R.L., White, P.C.L., Harris, S., 2004. Mortality due to fox predation in free-range poultry flocks in Britain. Vet. Rec. 155, 48–52.

Nakamura, K., Cook, J.K.A., Frazier, J.A., Narita, M., 1992. *Escherichia coli* multiplication and lesions in the respiratory tract of chickens inoculated with infectious bronchitis virus and/or *E. coli*. Avian Dis. 36, 881–890.

OIE, 2002. Office International Des Epizooties. Manual of Standards for Diagnostic Tests and Vaccines. http://www.oie.int.

Permin, A., Hansen, J.W., 1998. Epidemiology Diagnosis and Control of Poultry Parasites. FAO Animal Health Manual No. 4, Rome, 160 pp.

Permin, A., Pedersen, G., Riise, J.C., 2000. Poultry as a tool for poverty alleviation: opportunities and problems related to poultry production at village level. In: Alders, R.G., Spradbrow, P.B. (Eds.), Australian Centre for International Research (ACIAR) Proceedings No. 113 on SADC Planning workshop on Newcastle Disease Control in Village Chickens. pp. 143–147.

Rahman, M.H., Howlider, M.A.R., Rahman, S.M., Islam, J.M., 2003. Impact on parasitic infestations on the nutritional aspects of poultry birds under semi-scavenging condition in Bangladesh, PLDP Applied Research Project Final Report. Mymensingh, 111 pp.

Riise, J.C., Kryger, K.N., Seeberg, D.S., Chistensen, P.F., 2005. Impact of smallholder poultry production in Bangladesh—12 years experience with DANIDA supported livestock projects in Bangladesh. http://www.kvl.dk/upload/poultry/wokshop/w25/papers/riise.pdf.

Rodrigues, O.D., Nascimento, E., Do, R., Tortelly, R., Vogel, J., Nascimento, M., Do, F., Lignon, G.B., Mendonca, G.A.D.E., 2001. Damages caused on broiler chickens by the induced action of *M. gallisepticum* and *E. coli*. Vet. Bull. 72 (7) (Abstract No. 5023).

Talha, A.F.S.M., Hossain, M.M., Chowdhury, E.H., Bari, A.S.M., Islam, M.R., Das, P.M., 2001. Poultry diseases occurring in Mymensingh district of Bangladesh. Bangladesh Veterinarian 18 (2), 20–23.

White, P.C.L., Baker, P.L., Newton-Cross, G.A., Smart, J., Moberly, R.L., Mclaren, G., Ansell, R., Harris, S., 2000. Report on Contract 5: Management of the Populations of Foxes, Deer, Hares and Mink and the Impact of Hunting with Dogs and Report on Contract 6: Methods of Controlling Foxes, Deer, Hare and Mink for Lord Burns 'Committee of Inquiry into Hunting with Dogs. http://www.huntinginquirygov.uk/mainsections/huntingframe.htm, accessed 2004.