PEER REVIEWED

Fowl Pox and Newcastle Disease in African Smallholder Settings

Chickens are the most abundant livestock species in Africa. Free-range, indigenous chickens in smallholder village settings make up more than 80% of the poultry stocks in many of the countries in Africa (Queenan *et al.*, 2016). They provide 20% of animal protein and about 70% of all poultry products (Kitalyi, 1998) and often serve as petty cash for covering needs such as the purchase of medicines and school fees for children (Sultan *et al.*, 2011). Despite the importance of the free-range chicken production system on income generation and livelihood improvement of the rural African communities, this system faces key constraints due to high losses from diseases and poor productivity. Many governments and non-government organisations support activities to control poultry diseases (Alders *et al.*, 2009). This review illustrates poultry smallholders' challenges; the impact of Newcastle Disease and Fowl Pox; and disease control projects by governments and NGOs.

Smallholder Poultry Husbandry in Sub-Saharan Africa and Risk Factors for Losses

Chicken flocks in most African village settings are small, with a flock size of less than 100 birds. During the day chickens move freely and mix with flocks from different households, where they also breed. They are rarely provided feed supplements. At night they take shelter in their owners' house or in nearby trees or bushes. Usually children and women take care of smallholder chicken flocks (Safalaoh, 1997). Smallholder poultry husbandry systems have limited labour input and only occasionally is there an element of improvement such as supplementary feeds, care of chicks and treatment or vaccination against diseases. Apart from limited care, the indigenous birds are of low genetic potential in terms of poor growth rate, delayed maturing age (24 weeks), low feed conversion ratio, small body size and weight and few clutches (about three) per year (Sonaiya, 1990).

Many rural villages in low- and middle-income countries lack adequate animal health services (Sultan and Makundi, 2012) and are therefore likely to face losses due to diseases. Newcastle Disease is highly contagious and the most important poultry disease worldwide, especially in low- and middle-income countries. In Africa the disease occurs throughout the year and according to the AU-IBAR 2013 report (IBAR, 2013) it is ranked as the number one most deadly disease (see Figure 1). Mortalities due to Newcastle Disease may range from 50% to 100%. Studies have shown that outbreaks are influenced by locality, season, age of the bird and management system (Nwanta *et al.*, 2008).

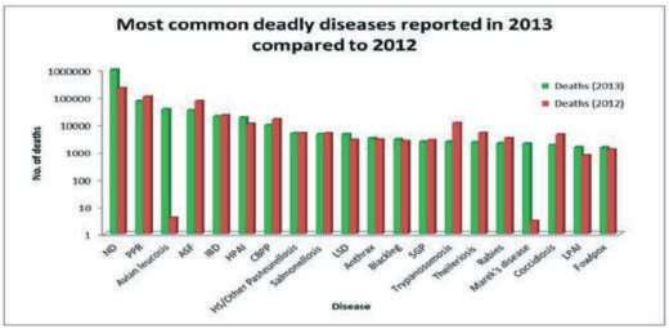

Figure 1. Most common deadly diseases reported in Africa in 2013 with Newcastle Disease ranking as number one, accounting for 77.77% of cases and 87.77% of deaths (source: IBAR Annual Report 2013)

Fowl Pox ranks second as a common disease of poultry, but unlike Newcastle Disease, it occurs sporadically and has a focal-seasonal transmission pattern as it depends mainly on mechanical transmission through biting insects, especially mosquitoes. It is difficult to control, since the virus can remain viable in the environment for up to ten years within pox scabs that have fallen off from sick birds.

Even if we set mortalities aside, there are indirect production losses due to diseases, because of low egg production, low egg hatchability, poor growth, and poor meat quality, and also socioeconomic losses such as lack of market and low prices are substantial (Mapiye *et al.*, 2008; Holmern and Røskaft, 2014).

Other causes of losses are predation, theft and accidents. Predator losses can be as high as 30%. Insufficient housing of chicks allows losses by predators such as cats, snakes, foxes, mongoose, hawks and dogs (Mapiye *et al.*, 2008, Holmern and Røskaft, 2014).

In summary, management of risk factors in indigenous village chickens in underserved rural areas is complex and requires collaboration of key stakeholders: primarily the poultry keepers, drug and vaccine retailers and distributors, livestock and veterinary staff, local and central governments, non-government organisations, research and development institutions and vaccine and drug manufacturers (Alders *et al.*, 2009).

Economic Impact of Newcastle Disease and Fowl Pox

Indigenous chicken meat and eggs are preferred by consumers in many countries and valued significantly higher as it is believed that such products are more tasty, organic and lack industrial chemicals such as antibiotics and biologicals like hormones. Economic losses due to Newcastle Disease and Fowl Pox arise primarily from the number of birds that die, and lowered productivity due to ill health.

At the household level, loss of birds and low productivity have adverse consequences on income and on many of the non-cash needs, such as meat and eggs as protein source for home consumption, manure as fertiliser for crops, gifts or loans for young entrepreneurs (people without capital are often loaned chicken to start a business to earn a living) and various rituals. Since indigenous poultry are owned mainly by women and children, both diseases may contribute to gender inequity. There is a long-term adverse effect on productivity as it takes time to replace the stock through breeding of the few birds that survive an outbreak episode.

Both diseases also have a detrimental effect on the income earned by various stakeholders that are involved

in the whole marketing system, e.g. village poultry vendors, motorbike transporters, local auction market wholesalers, local market revenue, transporters to towns and cities, and hotel workers (Queenan *et al.*, 2016). Indigenous chicken also provide employment mainly to youths and women that are involved in the whole production and marketing system of indigenous poultry meat and eggs.

A five-year project supported by FAO/IAEA on village poultry production in 11 countries in Africa clearly showed that vaccination against Newcastle Disease reduced mortality up to 80% coupled with substantial marginal returns, and was economically sustainable and recommended for low-input indigenous village poultry production in Africa (R. Klos *et al.*, 2004) (see Table 1). Supplementary feeding and improvement of housing may be profitable but does not provide consistent returns comparable to the use of vaccines. It has also been shown that housing provision for young chicks is a challenge in rural areas due to high costs of commercial feeds, and chicks sometimes ended up starving and dying (Msami *et al.*, 2004; Njue *et al.*, 2004).

Country		Profit (U.S.$)	Return (U.S.$)	Newcastle Disease Vaccination	Supplemental Feeding	Improved Housing
Cameroon	Ndop Zone	$0.18	$1.22	x		
Cameroon	Santa Zone	$10.00	$12.07	x		
Cote D'Ivoire	Group1	$33.46	$3.93	x		
Cote D'Ivoire	Group2	$637.48	$4.00	x	x	
Cote D'Ivoire	Group3	$62.66	$5.61	x	x	x
Ghana	Treatment	$403.83	$8.71		x	
Ghana	farmer given ND vac	$570.67	$155.88	x		
Kenya	control	$108.54	$1.85			
Kenya	1 Interv.	$59.87	$1.15		x	
Kenya	1 Interv.	$369.56	$3.36	x		
Kenya	2 Interv.	$178.92	$1.34	x	x	
Madagascar	Treatment 1	$18.33	$10.17	x		
Madagascar	Treatment 2	$33.06	$4.20	x	x	x
Mauritius	phase 1, zone 1	$51.90	$13.36	x		
Mauritius	phase 1, zone 2	$70.60	$17.81	x		
Mauritius	phase 2, zone2	$47.00	$1.60	x		x
Morocco	Intervention 1	$140.00	$2.40	x		
Morocco	Intervention 2	$471.00	$3.50	x	x	
Sudan	year 1	$642.00	$6.31	x		
Sudan	year 2	$1,610.00	$3.28	x		x
Sudan	year3	$2,190.00	$18.52	x		x
Tanzania	Intervention	$2,326.00	$3.49	x		
Uganda	montane region	$1,534.00	$2.81	x		
Uganda	agropastoral region	$1,093.00	$1.67	x		

Table 1: Partial budget assessment for the feasibility and efficiency of vaccination, supplementary feeding and housing interventions in family poultry operations in 11 African countries with Newcastle Disease vaccination intervention leading to most significant substantial returns (source: R. Klos et al., 2004).

Control of Newcastle Disease and Fowl Pox

Farmers' Approaches

Studies have shown that livestock keepers are knowledgeable and understand patterns of disease conditions under local settings. They are therefore key players during epidemiological studies, where they assist professionals in developing appropriate control and intervention strategies (Catley, Alders & Wood, 2012). The livestock keepers are home grown 'vets' and can make a diagnosis of most common diseases. In Tanzania, Newcastle Disease (Kiswahili: kideri) outbreaks occur throughout the year, but more so during the onset of the dry season. Once farmers learn about an outbreak of Newcastle Disease, their first remedy is often to sell or slaughter their flock or even give it away for free. Few farmers bury dead carcasses; but the majority feed them to stray dogs. Such practices further spread the disease.

Some farmers medicate their birds with various remedies, even those intended for human use or plant extracts, e.g. wild aloe, hot-peppers, lemon, or Neem (Azadirachta indica), in the belief that they can cure animal diseases (Okitoi *et al.*, 2007; Sultan *et al.*, 2011). Often such efforts are futile (Mtambo *et al.*, 1999) and losses continue. A limited number of studies indicate that crude extracts of plants such as aloe could be potential candidates for treatment of Newcastle Disease (Waihenya*et al.*, 2002; Abd-Alla *et al.*, 2012; Wang *et al.*, 2016), but more research is needed. For Fowl Pox, many farmers apply cooking oil to smoothen scabs, that close the birds' eyelids, and later remove them mechanically.

Overall, farmers' mitigation methods are often not effective and only a few farmers use vaccines. More efforts must be geared towards educating and involving farmers to control the diseases with efficacious vaccines at a wider coverage.

Governmental and Non-governmental Initiatives

Many central and local governments in Africa, together with their high-learning and research institutions, have for many years integrated their efforts to fight Newcastle Disease and Fowl Pox. While the governments' role has been primarily to provide financial and material support as well as policy and guidelines, the role of research institutions has been training of staff, improving existing vaccines, and developing new products. In Tanzania, for instance, the Tanzania Veterinary Laboratory Agency (TVLA) (formerly central veterinary lab) in collaboration with the Faculty of Veterinary Medicine at Sokoine University of Agriculture, has worked on the improvement and development of Fowl Pox and Newcastle Disease vaccines since the late 1990s. Initially through support from the Australian Centre for International Agricultural Research (ACIAR), TVLA started producing an I-2 Newcastle Disease vaccine. The I-2 strain is an avirulent Australian Newcastle Disease isolate and expected to provide a level of thermotolerance that is beneficial in a rural environment, where maintaining a cold chain is particularly challenging. Since then many improvements of the production and delivery system has taken place. At present the vaccine is commercially available in all regions in Tanzania. Its coverage has been improved through training farmers and stakeholders involved in the vaccine delivery chain. Similar efforts have been carried out on Fowl Pox research where, for instance in Tanzania, it was shown that a local Fowl Pox vaccine (strain TPV-1) was safe, thermotolerant immunogenic and efficacious in vaccinated chickens (Wambura and Godfrey, 2010).

To combat Newcastle Disease and Fowl Pox, control programmes – in line with national livestock disease control programmes – have been successfully carried out in African countries at national level or in collaboration between countries; in many cases supported by donor countries. The "Southern African Newcastle Disease Control Project (SANDCP)" was implemented in east and southern Africa, including several regions of Tanzania. Following the success of SANDCP, the "Strengthening food and nutrition security through family poultry and crop integration in Tanzania and Zambia" project was deployed in the two countries.

Many local and international organisations have for years integrated their efforts to fight Newcastle Disease and Fowl Pox in indigenous poultry in the smallholder setting, with the overall goal of improving economies and livelihood of rural communities. Activities included baseline surveys to establish the nature and extent of the diseases, development of new vaccines or improvement of existing vaccine, capacity building via training, supply of equipment and infrastructure and conducting interventions from simple pilot trials to wider scaling-up (see Figure 2).

The Global Alliance for Livestock Veterinary Medicines (GALVmed) is an international not-for-profit organisation

Figure 2. Community participation in immunisation against Newcastle Disease

that works in collaboration with partner organisations to improve animal health in order to improve the livelihood of farmers. Among GALVmed's most successful product development outputs were two I-2 Newcastle Disease vaccines, which are easy to transport and administer to poultry.

Several laboratory-based trials were conducted to offer field advice on vaccination programmes and vaccine storage, e.g.

- Comparison of the duration of immunity up to one year after vaccination of chickens against Newcastle Disease.
- Evaluation of the stability of inactivated and live Newcastle Disease vaccines after storing them at high temperatures.
- Assessment of a novel diluent technology as a potential tool to produce a liquid formulation of Newcastle Disease vaccine with improved stability and shelf-life.
- Development of a fast-dissolving tablet form of the vaccine to make it easier to deliver to smallholder farmers in remote areas.
- Development of combination vaccines offering protection against more than one important poultry disease in one shot.

A field-based project is currently being conducted by GALVmed in partnership with the Open University of Tanzania and Heifer International in Nepal to provide a vaccination approach that can be easily adopted by smallholder farmers for Fowl Pox and Newcastle Disease vaccinations; the aim is to show if the concurrent administration of live Fowl Pox and Newcastle Disease vaccines – given by non-invasive routes – is safe and efficacious under field conditions. The Fowl Pox vaccine will be administered via feather follicles (as such, a group of adjacent feathers will be plucked, and a vaccine-dipped brush will be rubbed inside the openings of the exposed holes of the feather follicles) at the time when birds are vaccinated against Newcastle Disease via eye-drop. This approach will make farmers less dependent on para-vets or vets during vaccinations.

Conclusion

This review illustrates that indigenous birds are the major source of income, protein and non-cash needs to rural African communities. Newcastle Disease and Fowl Pox are the most important diseases of indigenous chicken in African smallholder settings and continue to cause substantial economic losses. Disease control through vaccination reduces mortality and morbidity rates and is ranked as the most important strategy as it is coupled with equitable marginal returns. Further collaborative efforts by different organisations are needed to ensure a wide coverage and regular vaccinations against Newcastle Disease and Fowl Pox.

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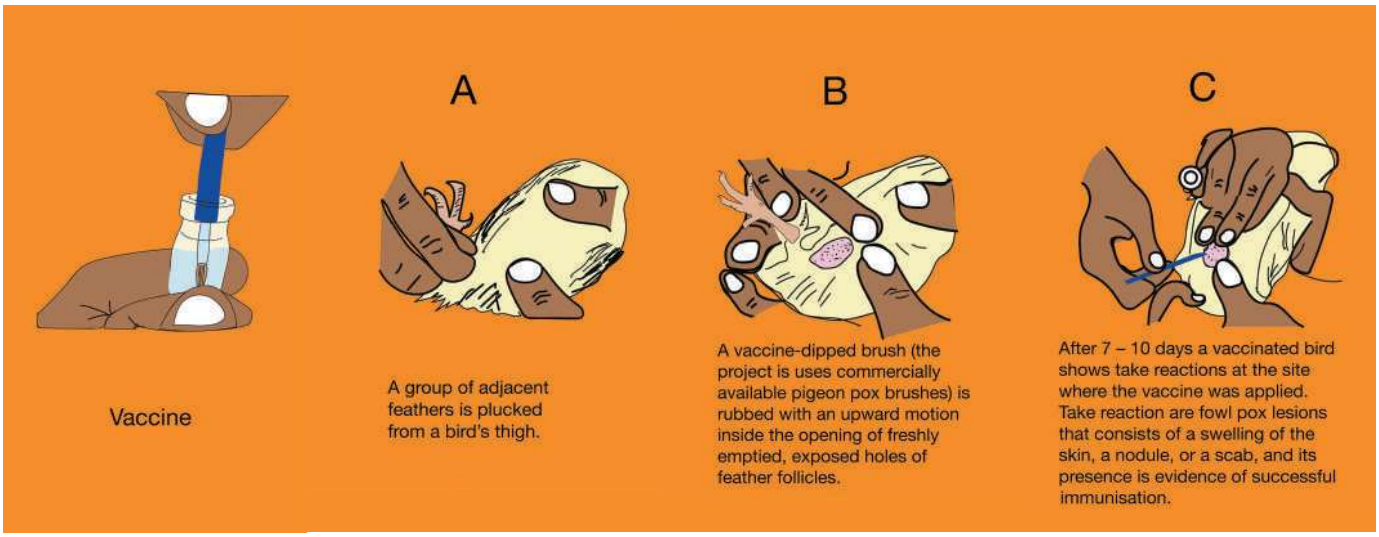

Figures 3 a-d: Fowl Pox vaccination by feather-follicle methodology

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