การประเมินความเสี่ยงของเชื้อไวรัสไข้หวัดนก สายพันธุ์ที่ก่อโรครุนแรงในสัตว์ปีก ในพื้นที่ลุ่มน้ำอิระวดี ประเทศพม่า

นาย ตัน ตัน วิน

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต
สาขาวิชาสัตวแพทยสาธารณสุข ภาควิชาสัตวแพทยสาธารณสุข
คณะสัตวแพทยศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย
ปีการศึกษา 2553

AREA RISK ASSESSMENT OF HIGHLY PATHOGENIC AVIAN INFLUENZA (HPAI) IN POULTRY IN AYEYARWADDY DELTA REGION, MYANMAR

Mr. Htun Htun Win

A Thesis Submitted in Partial Fulfillment of the Requirements

for the Degree of Master of Science Program in Veterinary Public Health

Department of Veterinary Public Health

Faculty of Veterinary Science

Chulalongkorn University

Academic Year 2010

Thesis Title	AREA RISK ASSESSMENT OF HIGHLY PATHOGENIC AVIAN INFLUENZA (HPAI) IN POULTRY IN AYEYARWADDY DELTA REGION, MYANMAR
By	Mr. Htun Htun Win
Field of Study	Veterinary Public Health
Thesis Advisor	Associate Professor Alongkorn Amonsin, D.V.M., Ph.D.
Thesis Co-advisor	Dr. Thanawat Tiensin, D.V.M., M.Sc.

Accepted by the Faculty of Veterinary Science, Chulalongkorn University in Partial Fulfillment of the Requirements for the Master's Degree

.....Dean of the Faculty of Veterinary Science
(Professor Mongkol Techakumphu, D.V.M., Doctorate de 3e cycle

THESIS COMMITTEE

.....Chairman
(Associate Professor Rungtip Chuanchuen, D.V.M., Ph.D.)

.....Advisor
(Associate Professor Alongkorn Amonsin, D.V.M., Ph.D.)

.....Co-Advisor
(Thanawat Tiensin, D.V.M., M.Sc.)

.....External Examiner
(Wantanee Kalpravidh, D.V.M., Ph.D.)

.....External Examiner
(Murray Maclean, B.V.Sc., M.V.S.)

ตัน ตัน วิน: การประเมินความเสี่ยงของเชื้อไวรัสไข้หวัดนก สายพันธุ์ที่ก่อโรครุนแรงในสัตว์ปีกในพื้นที่ลุ่มน้ำอิระวดี ประเทศพม่า (AREA RISK ASSESSMENT OF HIGHLY PATHOGENIC AVIAN INFLUENZA (HPAI) IN POULTRY IN AYEYARWADDY DELTA REGION, MYANMAR) อ.ที่ปรึกษาวิทยานิพนธ์หลัก: รองศาสตราจารย์ นายสัตวแพทย์ ดร. อลงกร อมรศิลป์, อ.ที่ปรึกษาวิทยานิพนธ์ร่วม: นายสัตวแพทย์ ธนวรรษ เทียนสิน, 77 หน้า

วัตถุประสงค์ในการศึกษาครั้งนี้คือ การศึกษาปัจจัยเสี่ยงของฟาร์มเปิดต่อเชื้อไวรัสไข้หวัดนก และการประเมินความเสี่ยงของเชื้อไวรัสไข้หวัดนกในพื้นที่บริเวณหมู่บ้านชาโปงในพื้นที่สามเหลี่ยมปากแม่น้ำอิระวดี สาธารณรัฐสหภาพพม่า ในการศึกษาปัจจัยเสี่ยงของฟาร์มเปิดต่อเชื้อไวรัสไข้หวัดนก ทำโดยการตอบแบบสอบถามของคนเลี้ยงเป็ด 50 คนในหมู่บ้านชาโปงและอีก 4 หมู่บ้านในพื้นที่เดียวกัน ผลจากการตอบแบบสอบถาม ได้นำมาวิเคราะห์การถดถอยโลจิสติกแบบตัวแปรเดียวและหลายตัวแปร เพื่อหาปัจจัยเสี่ยง ส่วนการประเมินความเสี่ยงของเชื้อไวรัสไข้หวัดนกในพื้นที่รอบสามเหลี่ยมปากแม่น้ำอิระวดีทำโดยการตรวจสอบวงจรการเลี้ยงและซื้อขายสัตว์ปีก ตรวจสอบหน่วยงานที่เกี่ยวข้องและตรวจสอบทางระบาดวิทยาของหมู่บ้านชาโปง ในการตรวจสอบวงจรการเลี้ยงและซื้อขายสัตว์ปีกในหมู่บ้านชาโปง ทำโดยการสอบถามผู้เกี่ยวข้อง 85 คน ผลการศึกษาแสดงให้เห็นว่าปัจจัยเสี่ยงที่มีนัยสำคัญของฟาร์มเปิดที่มีผลบวกทางซีรั่มวิทยาต่อเชื้อไวรัสไข้หวัดนก คือ กล่องใส่ไข่ที่ทำจากไม้ (OR = 52.66, 95% CI = 2.34-1.188x10^3, P = 0.013) และแหล่งที่มาของน้ำ (OR = 30.74, 95% CI = 1.96-481.64, P=0.015) ส่วนการทำความสะอาดกล่องก่อนนำมาใช้ใหม่ จัดเป็นปัจจัยป้องกันที่มีนัยสำคัญ (OR = 0.03, 95% CI = 0.00-0.42, P = 0.01) ในการประเมินความเสี่ยงของพื้นที่หมู่บ้านชาโปง ทั้งทางด้านการสัมผัสกับเชื้อและผลที่ตามมาพบว่าการประมาณความเสี่ยงของเชื้อไวรัสไข้หวัดนกต่อเป็ดและสัตว์ปีกที่เลี้ยงไว้หลังบ้านมีความเสี่ยงระดับปานกลางโดยที่มีความไม่แน่นอนในระดับต่ำ จากข้อมูลที่ได้ในการศึกษาครั้งนี้ การจัดการความเสี่ยงเน้นจำเพาะลงไปที่สัตว์ปีกที่เลี้ยงไว้หลังบ้านเพื่อป้องกันหรือลดความเสี่ยงของเชื้อไวรัสไข้หวัดนกในหมู่บ้านชาโปง

ภาควิชาสัตวแพทยสาธารณสุข ลายมือชื่อนิสิต.....
สาขาวิชาสัตวแพทยสาธารณสุข ลายมือชื่อ อ.ที่ปรึกษาวิทยานิพนธ์หลัก.....
ปีการศึกษา 2553 ลายมือชื่อ อ.ที่ปรึกษาวิทยานิพนธ์ร่วม.....

##5275559531 : MAJOR VETERINARY PUBLIC HEALTH

KEYWORDS : AVIAN INFLUENZA VIRUS / RISK FACTORS / RISK ASSESSMENT / AYEYARWADDY DELTA REGION / MYANMAR

HTUN HTUN WIN : AREA RISK ASSESSMENT OF HIGHLY PATHOGENIC AVIAN INFLUENZA (HPAI) IN POULTRY IN AYEYARWADDY DELTA REGION, MYANMAR

ADVISOR : ASSOC. PROF. ALONGKORN AMONSIN, D.V.M., Ph.D., CO-ADVISOR : DR. THANAWAT TIENSIN, D.V.M., M.Sc. 77 pp.

This study was aimed to identify the risk factors in duck farms and to conduct an area risk assessment of HPAI in Phyarpon township, Ayeyarwaddy delta region, Myanmar. Determination of risk factors for HPAI was conducted by questionnaire interviews with 50 duck farmers in Phyarpon and four surrounding townships. Results from the interviews and HPAI serological status in flock were used for determination of risk factors using univariable analysis and multivariable logistic regression. Area risk assessment was conducted by evaluating poultry supply chain, relevant institutional and epidemiological review of AI in Phyarpon. According to the poultry supply chain study in Phyarpon, focus-group discussion was conducted by interviewing 85 respondents. Our results showed that the significant risk factors for being HPAI seropositivity in ducks were using wooden box-egg containers (Odds ratio [OR] 52.66, 95% confidence interval [CI] 2.34-1.188x10^3, P=0.013) and using source of water from wetland (OR=30.74, 95% CI=1.96-481.64, P=0.015), while in reuse egg containers after cleaning was associated as protective factor (OR=0.03, 95% CI=0.00-0.42, P=0.01). Risk assessment of HPAI in Phyarpon including release, exposure and consequence assessment were qualitatively estimated. The results showed that overall risk estimation of HPAI for ducks and backyard chickens were moderate with low uncertainty. Based on the information of this study, risk management should be focused on the raising of backyard chickens and ducks to prevent or reduce risk of HPAI spread and infection in Phyarpon township.

Department : Veterinary Public Health ..... Student's Signature .....

Field of Study : Veterinary Public Health ... Advisor's Signature .....

Academic Year : 2010 Co-advisor's Signature .....

ACKNOWLEDGEMENTS

I would like to express my deep and sincere gratitude to the following individuals who helped in making for the present thesis:

First of all, Associate Professor Dr. Alongkorn Amonsin, my advisor for his excellent instruction, guide, advice and kind encouragement from the initial to final level enabled me to develop and understanding of this study.

Dr. Thanawat Tiensin, my co-advisor for all his support the way to analyze, excellent instruction, suggestion and powerful comments throughout the study period.

Associate Professor Dr. Rungtip Chuanchuen, the chairman of thesis committee; Dr. Wantanee Kalpravidh and Dr. Murray Maclean, the members of thesis committee for their critical and valuable suggestions.

Food and Agriculture Organization of the United Nations and the World Bank for their support in Scholarship and Research finances.

Director General Professor Dr. Myint Thein, Livestock Breeding and Veterinary Department, Myanmar for his permitting to study Master degree program in abroad.

Professor Dr. Kyaw Sunn, Research and Disease Control Division, Livestock Breeding and Veterinary Department for his supporting and advice in my research work.

All staffs from the Emerging and Re-emerging Infectious Diseases in Animals, Research Unit, Chulalongkorn University for their encouragement.

Dr. Kyaw Naing Oo for his advice and suggestions the ways to do field study, the way of data entry, coding and analyses.

All staffs from Epidemiology Unit, Research and Disease Control Division, Livestock Breeding and Veterinary Department for their participating in field study.

Finally for my family especially my father and mother for their encouragement, kindly supports and endless love.

CONTENTS

	Page
ABSTRACT (Thai)……....	iv
ABSTRACT (English)……..	v
ACKNOWLEDGEMENTS……....	vi
CONTENTS……...	vii
LIST OF TABLES……..	x
LIST OF FIGURES……	xii
LIST OF ABBREVIATIONS…….	xiii
CHAPTER I. INTRODUCTION……...	1
Objectives of study……...	4
Research questions……	4
Hypothesis of this study…….……	5
CHAPTER II. LITERATURE REVIEW…….	6
2.1 Morphology of avian influenza H5N1 virus……..……..……..	6
2.2 Geographic distribution, reservoir, mode of transmission and source of infection……..…….	6
2.3 Avian influenza (H5N1) outbreaks and control measures in Myanmar ……..……..……..	8
2.4 Risk assessment……..……..……..	11
CHAPTER III. MATERIALS AND METHODS……...	13

Page

Phase 1: Basic data collection based on records..…… 15

1.1 Basic data collection based on records in five townships …..…... 15

1.2 Questionnaires development and validation……..…... 17

Phase 2: Questionnaire based observational study…… 18

2.1 Risk factors study in five townships……..….. 18

2.2 Poultry supply chain study in Phyarpon township……. 20

2.3 Institutional review of Phyarpon township……... 20

2.4 Epidemiological review of HPAI in Phyarpon township…… 20

Phase 3: Risk factors and qualitative risk assessment analyses…….. 21

3.1 Risk factors analyses…….……... 21

3.2 Qualitative risk assessment analyses……..……... 21

CHAPTER IV. RESULTS…… 25

1.1 Basic data collection…….……... 25

2.1 Risk factors study in five townships……..…… 28

2.2 Poultry supply chain study in Phyarpon township……..… 29

2.3 Institutional review of Phyarpon township.……..…… 35

2.4 Epidemiological review of HPAI in Phyarpon township……..…. 35

3.1 Risk factors analyses……..……..…… 37

3.1.1 Univariable analyses……..…… 37

3.1.2 Multivariable analyses……..…. 40

3.2 Qualitative risk assessment of HPAI in Phyarpon township…….. 41

3.2.1 Feed……..…..……..... 43

3.2.2 Day-old chicks……..…….. 43

Page

3.2.3 Day-old ducks……... 44

3.2.4 Quail eggs……. 45

3.2.5 Chicken eggs…… 45

3.2.6 Duck eggs……. 46

3.2.7 Commercial layer and broiler chickens…… 46

3.2.8 Duck and chicken feather……... 47

3.2.9 Wild birds……...……... 48

3.2.10 Backyard chickens……..……... 50

3.2.11 Free-ranging ducks……...…….…… 51

3.2.12 Consequence assessment of HPAI outbreaks…… 52

CHAPTER V. DISCUSSION……... 53

5.1 Serological status of HPAI in duck farms in five townships, Ayeyarwaddy delta region…… 54

5.2 Risk factors of HPAI being seropositive in ducks in five townships, Ayeyarwaddy delta region ……..……..... 55

5.3 Poultry supply chain of Phyarpon township…… 57

5.4 Qualitative risk assessment of HPAI in Phyarpon township…… 58

5.5 Conclusions and suggestions…….. 60

REFERENCES ……. 62

APPENDICES……... 69

Appendix A. Duck farmer questionnaire form……. 70

Appendix B. Poultry supply chain questionnaire form……..…... 75

BIOGRAPHY……. 77

LIST OF TABLES

Table		Page
Table 1	Four epidemic waves of HPAI outbreaks in Myanmar during 2006 to 2010…….	9
Table 2	Classification of qualitative risk categories in the release assessment for facilitation of communication and interpretation…….	22
Table 3	Classification of qualitative risk categories in the exposure assessment for facilitation of communication and interpretation…….	23
Table 4	Combination matrix table for estimation of release, exposure and consequence risk assessment for HPAI……..	24
Table 5	Qualitative categories of uncertainty related to risk estimates…….	24
Table 6	Serological and virus isolation results of HPAI H5N1 in Pathein, Kangyihtaunt, Myaungmya, Phyarpon and Dedaye townships (2009)…….	26
Table 7	Import of poultry and poultry products to Phyarpon township based on questionnaire during April to June 2010…….	31
Table 8	Export of poultry and poultry products from Phyarpon township to neighbouring townships and other States or Divisions, based on questionnaire during April to June 2010……..	33
Table 9	Distribution of poultry and poultry products within Phyarpon township based on questionnaire during April to June 2010……...	34
Table 10	Epidemiological review of HPAI surveillance in duck in Phyarpon township from 2006 to May, 2010…….	36
Table 11	Results of univariable analyses of risk factors for highly pathogenic avian influenza (H5N1) virus infection in ducks in Ayeyarwaddy delta region…….	37

Page

Table 12 Results of multivariable logistic regression model for highly pathogenic avian influenza (H5N1) virus infection in ducks in Ayeyarwaddy delta region…… 40

Table 13 Results of qualitative risk estimation and associated uncertainties for release, exposure and consequence assessment of HPAI on poultry and poultry products in Phyarpon township…….. 42

Table 14 List of bird species observed in Phyarpon township……. 49

LIST OF FIGURES

Figure		Page
Figure 1	Map of study area, Ayeyarwaddy delta region, Myanmar…….	4
Figure 2	Map of HPAI H5N1 outbreaks in States and Divisions in Myanmar, during 2006 to 2010 (Outbreak States and Divisions are represent in gray color)……..	10
Figure 3	Diagram show the conceptual framework of the study…….	14
Figure 4	Map of Myanmar, showing the study area, Ayeyarwaddy delta region (gray colour)……...	16
Figure 5	Map of risk factors study area (five townships) in Ayeyarwaddy delta region, Myanmar……...	19
Figure 6	Duck population in study 5 townships, Ayeyarwaddy delta region….	25
Figure 7	Results of serological profile with the number of HPAI positive sera by detecting antibodies of HPAI H5N1 in five townships (2009)..…...	27
Figure 8	Poultry population in Phyarpon township including ducks, backyard and commercial chickens during 1 April to 30 June 2010…….....	29
Figure 9	Directional flows of imported and exported poultry and poultry products into and from Phyarpon township……	30

LIST OF ABBREVIATIONS

AI	Avian Influenza
°C	Degree Celsius
CI	Confidence Interval
et al.	et alii, and other
FAO	Food and Agriculture Organization
GPS	Global Positioning System
HA	Hemagglutinin
HI	Hemagglutination Inhibition
HPAI	Highly Pathogenic Avian Influenza
LBVD	Livestock Breeding and Veterinary Department
LPAI	Low Pathogenic Avian Influenza
NA	Neuraminidase
OIE	World Organization for Animal Health
OP	Oropharyngeal
OR	Odds ratio
PC	Permission certificate
SPSS	Statistical Package for Social Sciences

CHAPTER I

INTRODUCTION

Avian Influenza (AI) is caused by influenza A virus. This virus is an enveloped and single-stranded RNA virus belonged to the family *Orthomyxoviridae*. Avian influenza viruses can be classified into a number of subtypes based on sequence similarity of Hemagglutinin (HA) and Neuraminidase (NA), two major surface proteins on the envelope. There are 16 HA (H1-H16) and 9 NA (N1-N9) subtypes. The possible combination of HA and NA are 144 subtypes. Further classifications of AI virus are pathotypes based on their ability to cause disease in chickens. There are low pathogenic avian influenza (LPAI) and highly pathogenic avian influenza (HPAI). LPAI causes mild diseases in some bird species with no noticeable clinical signs. However, HPAI cause serious clinical signs on chickens with high mortality rate (nearly 100% within 48 hrs) and rapid spreading. Subtypes H5 and H7 are notified as a highly pathogenic avian influenza by the World Organization for Animal Health (OIE). HPAI H5N1 virus is highly contagious and causes disease in several species of birds, wild birds, food producing birds such as chicken, duck, turkey, quail, guinea fowl as well as domestic mammals, feline, canine and human (Amonsin et al., 2006; Rimmelzwaan et al., 2006; Songserm et al., 2006a; Abdel-Ghafar et al., 2008). Wild waterfowls especially ducks are natural reservoirs and important sources of influenza A virus infection to domestic birds and poultry (Easterday et al., 1997).

In Southern China, HPAI H5N1 virus emerged in the mid of 1990s (Li et al., 2004), and the first large-scale epidemic took place in the winter of 2003 in East and Southeast Asia (Alexander, 2007). Up to date there have been more than 6,500 HPAI H5N1 outbreaks reports from 63 countries and human cases from 15 countries (WHO, 2010). HPAI H5N1 had serious impact on poultry production in Southeast Asia during the last ten years (Henning et al., 2009a). The affected countries face with human death as well as poultry death and culled to reduce the spread of diseases. In addition, local and

international trades ban on poultry and poultry products. Moreover, poultry production structures, density of wet markets, local trade patterns, control and preventive efforts are believed to influence the virus dissemination (Tiensin et al., 2009). The introduction of AI virus to poultry farms mainly occur by direct or indirect contact with infected birds and resulting from the movement of wild birds, live poultry, people, vehicles, equipments or contaminated materials (Stegeman et al., 2004; Capua and Marangon, 2006). The movement of animals also played a key role in disease transmission (Stegeman et al., 2004; Boender et al., 2007).

In Southeast Asia, poultry and people may be in a close contact and infect with AI virus through a complex chain activities of socioeconomic situation concerned with raising, buying and selling activities of poultry and poultry products (McLeod et al., 2009). The control of HPAI outbreaks in poultry has been attempted as a regional and global priority. Hong Kong and Thailand has been reported to be successful in the control of HPAI outbreaks by culling of birds on infected premises and intensive surveillance (Sims et al., 2003; Tiensin et al., 2005). However, in the case of some countries in Southeast Asia including Myanmar where there is a high density of ducks, backyard poultry and small poultry enterprises, many difficulties in controlling of disease are still challenging.

Myanmar had been a country free from HPAI until early 2006. The first report of HPAI outbreaks occurred in February 2006. There were four epidemic waves of HPAI outbreaks in Myanmar during 2006 to 2010. More than 816,000 bird deaths (mortality and culling) and a non-fatal human case were recorded from these four waves. The source of virus was assumed to be from the migratory birds or water fowls or from the cross-border trade of poultry (Mon et al., 2008b). Myanmar is considered as a country with high risk for HPAI spread because of backyard poultry production system and sharing border with several countries in South and Southeast Asian region while control measures against the cross-border trade contact are still weak. The impacts of this disease could be a great burden to the national economy relying on the agricultural enterprises and backyard livestock husbandry system.

Ayeyarwaddy delta region is the main agricultural and rice growing area of the country located in Southern West of Myanmar. This region has high density of duck and backyard chicken populations with low biosecurity (Mon et al., 2008a). According to the report of Myanmar Eco Tourism, Meinmahla Kyun wetland is located in this region with 34 bird species observed. These bird species and ducks use the paddy field as a feeding ground to graze around (Mon et al., 2008a). There have been reported that the paddy field is a place of association between HPAI H5N1 virus and free grazing ducks, and a critical factor for the persistence and spread of HPAI virus (Gilbert et al., 2006). Most of poultry and poultry products from this region are being distributed not only within the region but also to other States and Divisions. There have been reported that movement of live birds, contaminated transport vehicles and materials increase the chance of HPAI spread to poultry (Thomas et al., 2005; Kung et al., 2007; Biswas et al., 2008). Therefore, it is essential to conduct the risk factors study in duck farms in Phyarpon township and four surrounding townships and the area risk assessment of HPAI in Ayeyarwaddy delta region, Myanmar. Risk assessment is one of the component of risk analysis framework, which consists of four components, namely hazard identification, risk assessment, risk management and risk communication (Muarry et al., 2004). This study was focused on the risk assessment in a selected township, Phyarpon.

In this study, risk factors of HPAI in duck farms in five townships and area risk assessment of HPAI in Phyarpon township, Ayeyarwaddy delta region and the likelihood of introduction and transmission of HPAI virus into the area have been identified to provide the risk management and risk communication for HPAI control and prevention in Myanmar (Figure 1). The outcomes of this study will provide a partial support to some extents in the management for control and prevention of HPAI H5N1 outbreaks in Myanmar in the future.

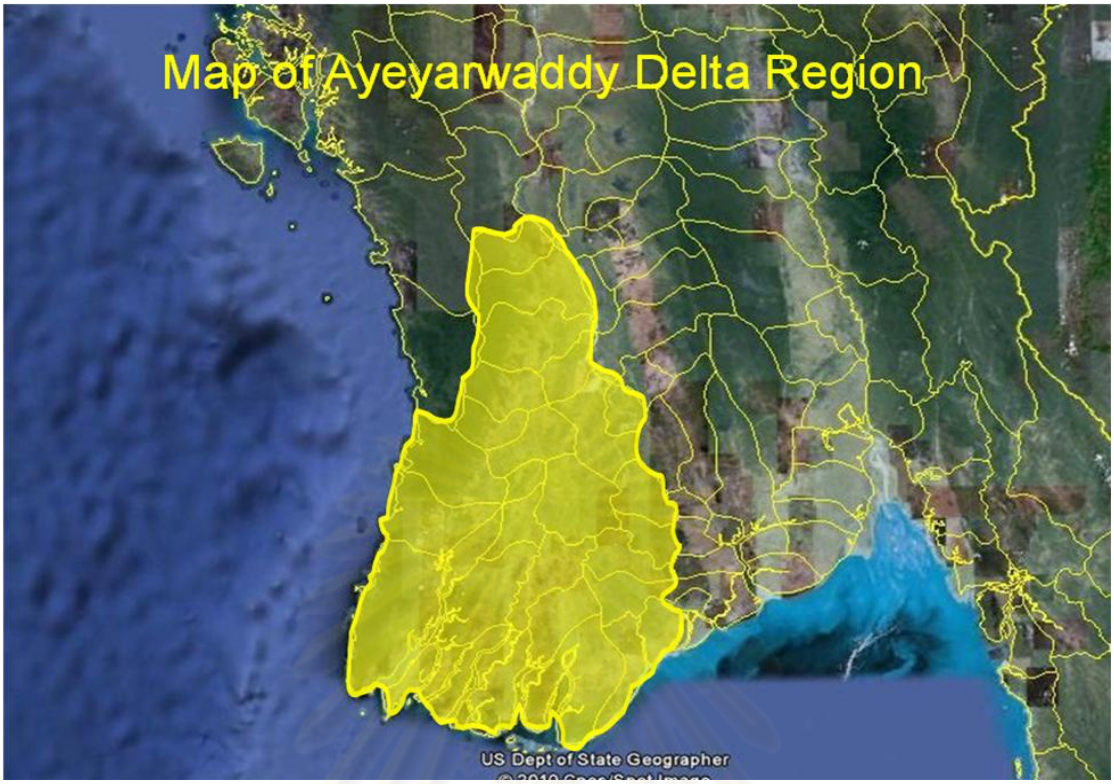

Figure 1 Map of study area, Ayeyarwaddy delta region, Myanmar

Objectives of study

1. To identify the risk factors in seropositive duck farms from five townships, Ayeyarwaddy delta region, Myanmar.
2. To conduct the area risk assessment of HPAI in Phyarpon township, Ayeyarwaddy delta region, Myanmar.

Research Questions

1. What are the risk factors in HPAI seropositive duck farms from five townships, Ayeyarwaddy delta region, Myanmar?
2. How is the risk of HPAI in Phyarpon township, Ayeyarwaddy delta region, Myanmar?

Hypothesis of this study

1. Some risk factors in duck farms may associate with HPAI seropositivity in ducks from five townships, Ayeyarwaddy delta region.
2. Area risk assessment in Phyarpon township, Ayeyarwaddy delta region may imply the possibility that Phyarpon township is an area of HPAI risk.

CHAPTER II

LITERATURE REVIEW

2.1 Morphology of avian influenza H5N1 virus

Influenza viruses are belonged to the family *Orthomyxoviridae*. These viruses are classified into three types namely A, B, and C based on the antigenically related with their nucleoprotein (NP) and matrix (M) proteins. Type A influenza viruses naturally infect humans, horses, swine, and birds, while in type B and C infect mainly in humans. The viruses are irregular spherical particles and the virion envelope is gained from the host cell membrane. There are two distinct types of surface spikes as peplomers which one has a rod-shaped and the other one is mushroom-shaped. All strains of influenza can agglutinate erythrocytes of human, guinea pigs and chickens as well as many other species (Ardans and MacLachlan, 2004). There are 16 recognized influenza HA (H1-H16) subtypes, and the antibodies against the HA prevent infection of host cells. There are 9 recognized NA (N1-N9) subtypes. According to their ability to cause disease symptoms and fatality, AI viruses can be classified into highly pathogenic avian influenza (HPAI) and low pathogenic avian influenza (LPAI). High mortality rate and systematic disease are seen in HPAI-infected poultry, whereas only profound morbidity, weight loss and mild symptoms are found in LPAI-infected birds (Burgos and Burgos, 2007).

2.2 Geographical distribution, reservoir, transmission and source of infection

Avian influenza virus especially highly virulent strain is a major threat to the world's poultry industry. Since 2003, the disease has spread widely in 63 countries across Asia, Europe, Africa and the Middle East (FAO EMPRES, 2010). In wild birds, virus replication mainly occurs in the intestinal tract of hosts. The virus shedding occurs in feces, and afterwards, is transmitted by fecal-oral route (Burgos and Burgos, 2007). The widely

acceptable natural reservoirs of HPAI are wild birds, duck and geese without showing any symptoms (Hinshaw et al., 1980; Tumpey et al., 2002; Webster, 2002). Some waterfowl species are able to shed virus for up to 5 days before showing any disease symptoms. It is suggested that these birds are able to potentially spread virus within limited areas without being long-term reservoirs of the virus. Migratory birds are the main reservoirs as well as the transmission media for HPAI virus. It was supposed that distribution and activities of migratory birds may help the spread of HPAI throughout the world recently (Jing et al., 2007). Wetlands, rivers and lakes are the major habitat sites for several migratory birds, and contaminated water and soil are the major transmission sources of HPAI (Jing et al., 2007). In addition, globalization, international and domestic trade (legally and illegally), marketing practices (live bird markets), farming practices (grazing and farming), as well as the presence of the viruses in wild birds can contribute to the spread of AI viruses through direct contact with secretion of infected birds, especially feces or through contaminated feed, water, equipment, vehicles and clothing.

Disruption of transmission pathway of HPAI and identifying the risk factors of HPAI in duck farms are essential to design effective control measures. In Vietnam, insufficient vaccination of HPAI, receiving visitors to the farms, geese present in the farm and sharing of scavenging areas with ducks from other farms showed that increased risk of HPAI outbreaks on small holder duck and chicken farms (Henning et al., 2009b). In Bangladesh and Thailand, feeding poultry with the remains of slaughtered purchased chickens, proximity to a body water, having contact with pigeons and farms where owners bought live chickens from a another backyard farms also found that higher risk of HPAI infection in backyard chickens (Biswas et al., 2009; Paul et al., 2011). It have been reported that paddy fields are a place of critical factors between HPAI virus and free-grazing ducks (Gilbert et al., 2006). Reducing those risks may help prevention and control of HPAI infection in poultry.

2.3 Avian influenza (H5N1) outbreaks and control measures in Myanmar

In Myanmar, outbreaks of highly pathogenic avian influenza H5N1 have caused the economic losses and public health consequences as well as social impacts. The course of avian influenza H5N1 in Myanmar consisted of four epidemic waves (Table 1 and Figure 2) and repeated disease reoccurrences throughout 2007. The first wave began in central part of Myanmar, especially Mandalay and Sagaing Divisions in March 2006 with affected 545 farms. This first wave was more serious and wider spread than the other three waves but it was stopped in a month. The second wave occurred in lower part of Myanmar, Yangon Division in March 2007 and the infection spread to Bago Division and Mon State till October 2007. During this wave, fatal cases of ducks were recorded in Thanatpin township, Bago-East Division, a specialized duck raising area. The third wave occurred in Eastern-Shan State bordering with China and Thailand, starting with movement of ducks from Mong La (border area). Village chickens and ducks were affected in this wave and also a non fatal human case was recorded (Mon et al., 2008b). The last wave appeared in two townships of Yangon and one township of Sagaing Division in February and March 2010. Stamping-out policy, quarantine and movement restriction, zoning and compartmentalization, hygienic measures, tracing and post-outbreak surveillance were carried out in all outbreak areas (e.g., culling poultry and poultry products, zoning and disinfection of premises) according to the contingency plan (LBVD, 2007). Movement of poultry, poultry products and related materials outside the affected areas was strictly prohibited with the help of local authorities.

After each outbreak, intensive post-outbreak surveillance was conducted by Livestock Breeding and Veterinary Department (LBVD) on poultry in the HPAI affected townships at 21 days after the last case. In the same areas, regular active surveillance was done two times per year, at six month interval according to the FAO guidelines (FAO, 2004).

In Ayeyarwaddy delta region, there was no reported HPAI outbreak during 2006 to 2010. After the first wave of HPAI outbreaks in central Myanmar, this delta region was

identified as a HPAI high risk area according to the high density of duck population (Mon et al., 2008a). Since 2007, LBVD conducted regular HPAI active surveillance especially in ducks by collecting serum samples and cloacal swabs. In 2008 surveillance, antibodies of HPAI were detected from the collected duck serum samples but the virus was not detected from all cloacal swabs of seropositive and seronegative ducks.

Table 1 Four epidemic waves of HPAI outbreaks in Myanmar during 2006 to 2010

	First wave	Second wave	Third wave	Fourth wave
Year	2006	2007	2007	2010
Outbreak areas	Mandalay Division Sagaing Division	Yangon Division Bago Division Mon State	Eastern-Shan State	Yangon Division Sagaing Division
Affected townships	13 townships	12 townships	2 townships	3 townships

Figure 2 Map of HPAI H5N1 outbreaks States and Divisions in Myanmar, during 2006 to 2010 (Outbreak States and Divisions are represent in gray color)

2.4 Risk assessment

Risk is commonly described as a probability or threat of a damage, injury, loss or other negative occurrences that caused by a hazard or a source of danger. Alternatively, risk is expressed as a mathematical combination of the probability of the occurrence of accidents and the probability of the effect of its consequences (Kaplan, 1997).

Risk assessment is the process of evaluation of the likelihood and biological, environmental, economic, and public health consequences of the entry, establishment and spread of a disease. It is widely accepted as a systematic process for qualitatively or quantitatively describing risk. It consists of four steps, namely release assessment, exposure assessment, consequence assessment and risk estimation (Muarry et al., 2004). Risk assessment is concerned the determination of quantitative and qualitative value of risk which is related to the threat of disease. Qualitative risk assessment measures are allowed to quick process to identify potential risk. It is helpful to determine the likelihood of HPAI introduction, transmission and its associated consequences. Release assessment seeks to identify the likelihood of potential pathways for HPAI virus introduction into a particular environment by imported poultry and poultry products being infected or contaminated with HPAI virus. Exposure assessment consists of determining the biological pathways of HPAI virus leading to exposure of susceptible birds. Consequence assessment aims to describe the severity of the event in biologic, as well as economic concerns and public health intervention. Risk estimation is the combination of the results from the release assessment, exposure assessment and consequence assessment to produce a summary measure of the risk associated with HPAI (Muarry et al., 2004).

Risk is characterized with two particular elements such as hazard and uncertainty (quantified by probability) (Bedford and Cooke, 2001). Uncertainty is meant lack of certainty that a state of having limited knowledge where it is unable to describe existing condition or

future outcomes of risk. Risk assessment and multiple type of uncertainty are often complicated.

HPAI is considered one of the most important devastating disease of poultry as well as a severe trade restriction of poultry and poultry products. Recently, most of the countries are considering for the elimination of HPAI virus from domesticated poultry with various ways. Qualitative risk assessment is one of most common tool of HPAI risk estimation to provide risk management and risk communication.

CHAPTER III

MATERIALS AND METHODS

This study consisted of 3 phases; **Phase 1:** Basic data collection based on records in five townships (Pathein, Kangyihtaunt, Myaungmya, Phyarpon and Dedaye) Ayeyarwaddy delta region, Myanmar, **Phase 2:** Questionnaire based observational study, **Phase 3:** Risk factors and qualitative risk assessment analyses. The conceptual framework of this study is shown in Figure 3.

In this study, basic data collection based on records was focused on duck population from five townships and serological results in duck cross-sectional study in 2009, Epidemiological Unit, LBVD. After basic data collection, two questionnaires were developed including risk factor questionnaire and poultry supply chain questionnaire. Risk factor questionnaire was used to study risk factors in duck farms in five townships including Pathein, Kangyihtaunt, Myaungmya, Phyarpon and Dedaye, in Ayeyarwaddy delta region. This study was conducted based on case-control study by questionnaire interview with 50 duck farmers in those five townships and then evaluated the association between factors and being HPAI seropositivity in ducks.

Qualitative risk assessment was conducted in Phyarpon township by evaluating the information from poultry supply chain study, institutional and epidemiological review of avian influenza. Poultry supply chain study was conducted based on focus-group discussion by questionnaire interview with 85 respondents in Phyarpon township by using poultry supply chain questionnaire. For institutional and epidemiology review, the required data was requested from Phyarpon's LBVD and Epidemiology unit. Finally, qualitative risk assessment of HPAI in Phyarpon township was done by analyzing all information. All are explained in detail step by step as following.

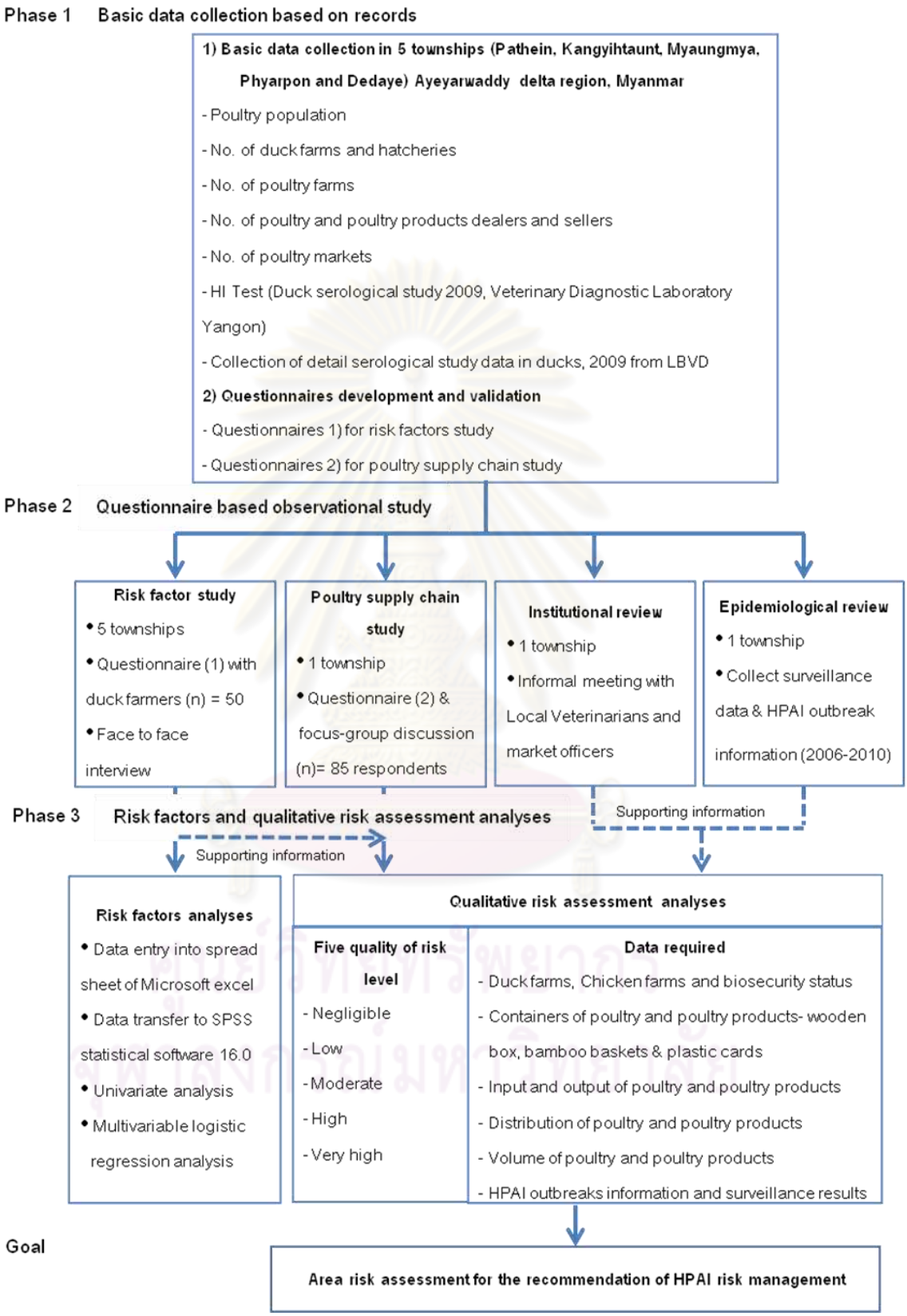

Figure 3 Diagram show the conceptual framework of the study

Phase 1: Basic data collection based on records

1.1 Basic data collection based on records in five townships (Pathein, Kangyihtaunt, Myaungmya, Phyarpon and Dedaye), Ayeyarwaddy delta region, Myanmar (Figure 4 and 5)

The criteria for the selection of five townships to study the risk factors of HPAI for being seropositivity in ducks were in accordance:

1) high density of duck population
2) major paddy field and water flood areas
3) moderate movement of poultry and poultry products

From those five townships, Phyarpon township was selected to study the area risk assessment of HPAI with these additional criteria:

1) close to a wetland (Mainmahla Kyun)
2) the history of HPAI seropositive in duck in 2008 surveillance
3) high movement of poultry and poultry products

Basic data of those five townships were collected from the local veterinarians by arranging informal meeting, interviewing and recording. The data records were focused on the poultry population, number of duck hatcheries, number of poultry farms, and number of feed, day-old chicks, live poultry and egg dealers, number of poultry meat and egg sellers, and number of small live bird markets. In addition, duck serological status in 2009 cross-sectional study was acquired focusing on duck farms examined in each township from the epidemiology unit, LBVD. In duck cross sectional study 2009, HI test was used to detect antibody of HPAI virus in duck sera. Virus isolation was conducted to detect the virus from oropharyngeal swabs if the serum samples showed positive. After collection of data, questionnaires were developed for field study.

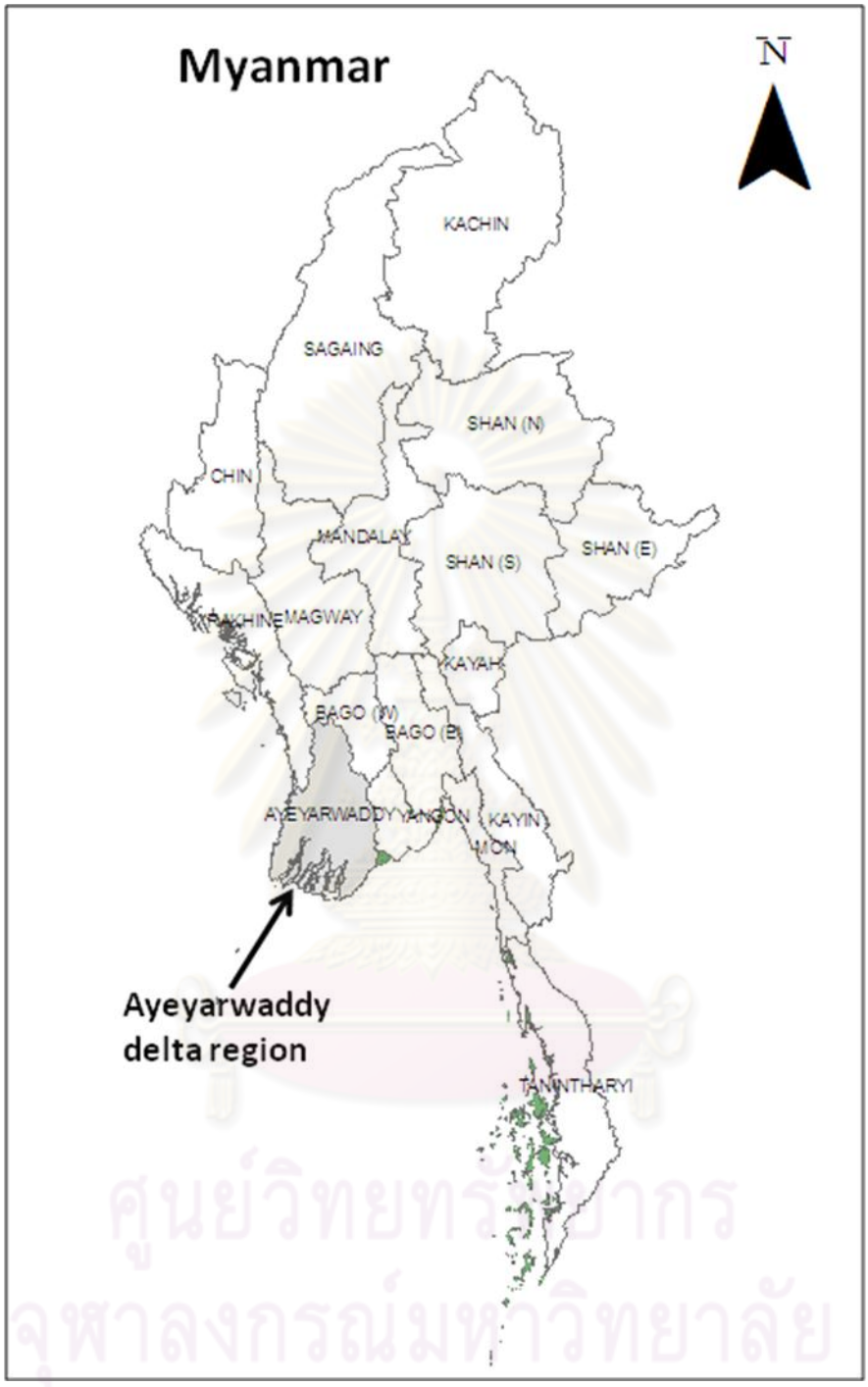

Figure 4 Map of Myanmar, showing the study area, Ayeyarwaddy delta region (gray colour)

1.2 Questionnaires development and validation

In this study, two types of questionnaires including risk factor questionnaire and poultry supply chain questionnaire were developed. Close-ended questionnaires were used as well as face-to-face interview. The questionnaires were tested at field level to cooperate with local veterinarians. After implementing the questionnaires, the survey was conducted during April to June, 2010.

1.2.1 Risk factor questionnaire (Appendix A)

This questionnaire development was based on including the information of duck farms, farm managements, farming systems, environmental factors, biosecurity status and farmer's knowledge of HPAI. The risk factor questionnaire set was included 40 questions. This questionnaire was used to interview participants in 5 townships.

1.2.2 Poultry supply chain questionnaire (Appendix B)

This questionnaire was developed including the information of types of poultry and poultry products, source, distribution, volume, purchase and selling price of poultry and poultry products, type of container and mode of transportation of poultry and poultry products. This poultry supply chain questionnaire set was included 13 questions. This questionnaire was used to interview participants in Phyarpon township.

Phase 2: Questionnaire based observational study

2.1 Risk factors study in five townships (April to June 2010)

Risk factors study in five townships including Pathein, Kangyihtaunt, Myaungmya, Phyarpon and Dedaye were conducted base on case-control study by individual interview with risk factor questionnaire to duck farmers (n=50) who participated in the 2009 ducks serological study (Figure 5). Case and control selection were based on the results of 2009 ducks cross-sectional study that requested from Epidemiology Unit, LBVD. The study five townships were selected in 2009 ducks cross-sectional study for HPAI surveillance in ducks. This cross-sectional was conducted based on multistage sampling. Firstly, five village tracts were randomly selected from those townships. Secondly, two ducks farms were randomly selected from each selected village tract. From each selected duck farms, 30 serum samples and oropharyngeal swabs were collected. HI test and virus isolation were used to detect the antibodies of HPAI and HPAI virus. Based on HI test results, seropositive farms were selected as a case farm and seronegative farms as a control farm. Twelve case and 38 control duck farms were selected with a case-control ratio of 1:3. These case and control farms did not matched based on their locations.

Questionnaire interviews were conducted together with five trained veterinarians from the Epidemiology Unit, LBVD. Interviews were conducted in Burmese and answers were recorded on printed copies of the questionnaire in English. Time consuming for each interview was on average 30 minutes.

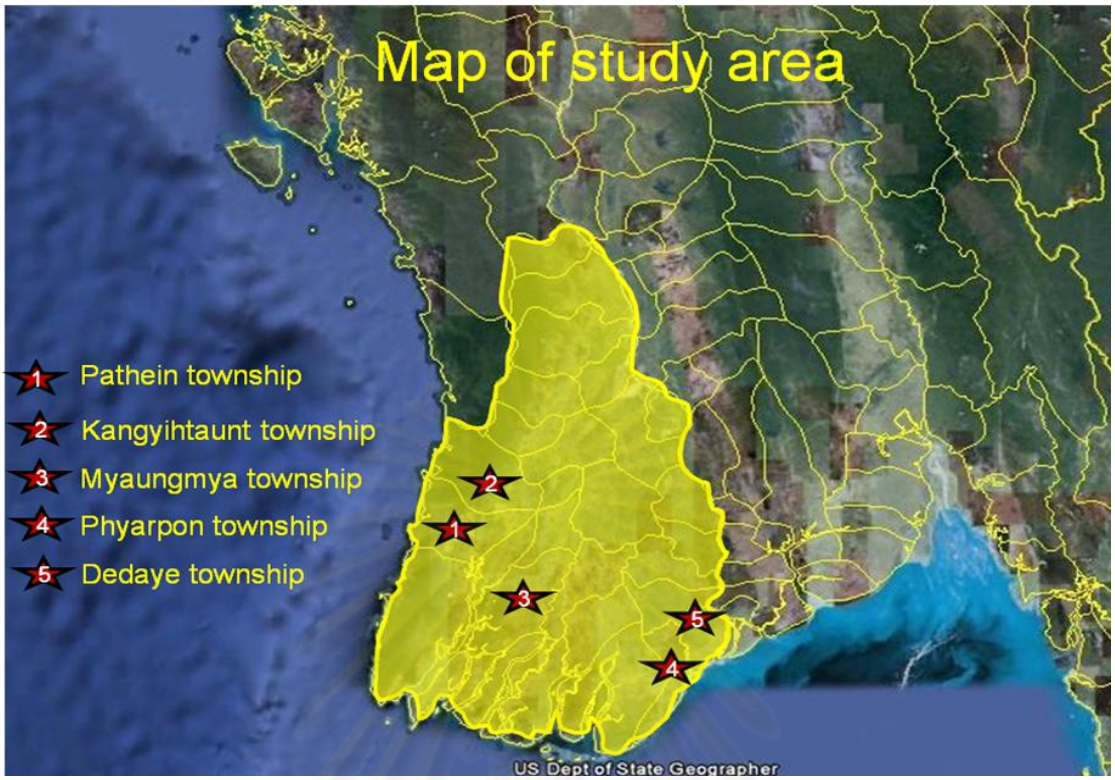

Figure 5 Map of risk factors study area (five townships) in Ayeyarwaddy delta region, Myanmar

2.2 Poultry supply chain study in Phyarpon township (April to June 2010)

Poultry supply chain study was conducted by focus-group discussion and questionnaire interview with poultry supply chain questionnaire to respondents (n=85). Eighty five respondents were local veterinarians, market officers, duck hatchery owners, poultry farmers, feed, day-old chicks, live poultry and egg dealers, poultry meat and egg sellers and duck feather dealers. Field observation and marking GPS points were also conducted. The studied types of poultry and poultry products were focused on day-old ducks, day-old chicks, day-old quails, feed, chickens (village chickens, layers and broilers), ducks, eggs (ducks, chickens and quails), duck and chicken's feathers. Supply chain respondents including commercial duck and chicken farmers were randomly selected. Dealers and sellers were selected with the help of market officers and the information provided by the commercial duck and chicken farmers. The participants for focus group discussion were market officers and local veterinarians who participated in all supply chain study.

2.3 Institutional review of Phyarpon township

Institutional review was conducted by data acquisition from LBVD of Phyarpon township. The information were collected based on legislation related to poultry farm registration and poultry movement, as well as the activities of surveillance, control and prevention of HPAI. All this information was supported for risk assessment of HPAI in Phyarpon.

2.4 Epidemiological review of HPAI in Phyarpon township

Epidemiological review was carried out by data acquisition from the Epidemiology Unit, LBVD. In this review, surveillance activities and outbreak situation of HPAI were reviewed with the organization of Epidemiology Unit, LBVD. The information from epidemiological review was supported for risk assessment of HPAI in Phyarpon.

Phase 3: Risk factors and qualitative risk assessment analyses

3.1 Risk factors analyses

The data from questionnaire was coded and entered into a spread sheet of Microsoft Excel and transferred to SPSS statistical software 16.0 for analysis. To examine the association and statistical significance between risk factors and HPAI being seropositive in duck farms, univariable analysis was computed. Any variables with P value ≤ 0.25 after univariate analysis was included for further analysis. Variables was considered for plausible biologically relation before further analysis. Multivariable logistic regression was conducted for association between risk factors and HPAI being seropositive in duck farms. Final multivariable logistic regression model was fitted by a backward stepwise-Wald process. Finally, model fit was assessed using Hosmer-Lemeshow goodness-off-fit test and the ratio of the deviance to the degree of freedom. An association was considered as a significant if the P value is ≤ 0.05.

3.2 Qualitative risk assessment analyses

Qualitative risk assessment analyses of HPAI in Phyarpon township were conducted based on data from three components.

A) Poultry supply chain study

B) Institutional review

C) Epidemiological review cooperated by LBVD and FAO.

Poultry supply chain study, institutional and epidemiological review were provided the required information of imported and exported poultry and poultry products from HPAI outbreak areas, poultry and poultry products movement, legislation relating with poultry farm registration and checking of poultry and poultry products, HPAI outbreaks information and surveillance results to the analysis of qualitative risk assessment. Qualitative risk assessment was consisted of four steps including release assessment, exposure

assessment, consequence assessment and risk estimation of HPAI (Muarry et al., 2004). Overall risk estimation of HPAI in Phyarpon township were conducted by combining release, exposure and consequence assessment. The levels of risk estimation were arranged in an order to five levels including negligible, low, moderate, high and very high (EFSA, 2006). These categories were assessed by mean of the following descriptive scale:

1) Negligible means the probability is not occur.

2) Low means the probability is unlikely.

3) Moderate means the probability is likely.

4) High means the probability is very likely and

5) Very high means the probability is almost certain.

The estimation of release assessment and exposure assessment was based on mainly HPAI outbreaks information, surveillance results, data from poultry supply chain questionnaire including duck farms, chicken farms and their biosecurity status, imported and exported poultry and poultry products, distribution and volume of poultry and poultry products (Table 2 and 3) (Kasemsuwan et al., 2009). The consequence assessment was considered the impact of HPAI outbreaks, if outbreaks could occur in poultry in Phyarpon township.

Table 2 Classification of qualitative risk categories in the release assessment for facilitation of communication and interpretation

Risk	Frequency of occurrence of HPAI outbreaks in township level during 2006-2010	Seroprevalence of HPAI (%)
Negligible	No outbreak	0
Low	1 time per year	1-5
Moderate	2-3 times per year	5-10
High	1 time per month	10-20
Very high	1 time per week	>20

Table 3 Classification of qualitative risk categories in the exposure assessment for facilitation of communication and interpretation

Risk	Probability of transmission of HPAI H5N1 virus that introduced into Phyarpon township to domestic poultry
Negligible	1 %
Low	2-25 %
Moderate	26-50 %
High	51-75 %
Very high	76-100 %

The overall risk estimation was identified according to the multiplying of the release assessment, exposure assessment and consequence assessment of HPAI in Phyarpon township (Table 4). The resulting overall risk was a conditional probability; the risk estimation could not be higher than the probability of release risk. If the risk estimation was negligible in the release assessment, the risk for exposure assessment and consequence assessment would be not considered. In addition to the risk estimation, the levels of uncertainty of data (low, moderate, high and not known) were described in the results of this risk estimate (Table 5) (EFSA, 2006; Kasemsuwan et al., 2009).

Table 4 Combination matrix table for estimation of release, exposure and consequence risk assessment for HPAI

		Exposure and consequence assessment				
		Very High	**High**	**Moderate**	**Low**	**Negligible**
Release assessment	**Very High**	Very High	High	Moderate	Low	Negligible
	High	High	Moderate	Moderate	Low	Negligible
	Moderate	Moderate	Moderate	Moderate	Low	Negligible
	Low	Low	Low	Low	Negligible	Negligible
	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible

Table 5 Qualitative categories of uncertainty related to risk estimates

Uncertainty category	Interpretation
Low	There are solid and complete data available; strong evidence is provided in multiple references; authors report similar conclusions.
Moderate	There are some but no complete data available; evidence is provided in small number of references; authors report conclusions that vary from one another.
High	There is scarce or no data available; evidence is not provided in references but rather in unpublished reports or based on observations, or personal communication; authors report conclusions that vary considerably between them.
Not known	There is no data available, no reference, no personal communication, and no experience.

CHAPTER IV

RESULTS

1.1 Basic data collection

Basic data collection from five townships including Pathein, Kangyihtaunt, Myaungmya, Phyarpon and Dedaye was based on duck population and HPAI serological surveillance results in 2009. Based on data of 2009 ducks cross-sectional study, duck population were 72,417 in Pathein, 101,184 in Kangyihtaunt, 491,276 in Myaungmya, 81,203 in Phyarpon and 170,377 in Dedaye township (Figure 6). Firstly, five village tracts were randomly selected from each township. And then two duck farms were randomly selected from each selected village tract to collect blood samples and oropharyngeal swabs. Ten duck farms were selected from each township. Thirty serum samples and 30 oropharyngeal swabs were collected from each duck farm. The collected serum samples were detected antibodies against HPAI virus using HI test. The collected oropharyngeal swabs were detected HPAI virus using egg inoculation.

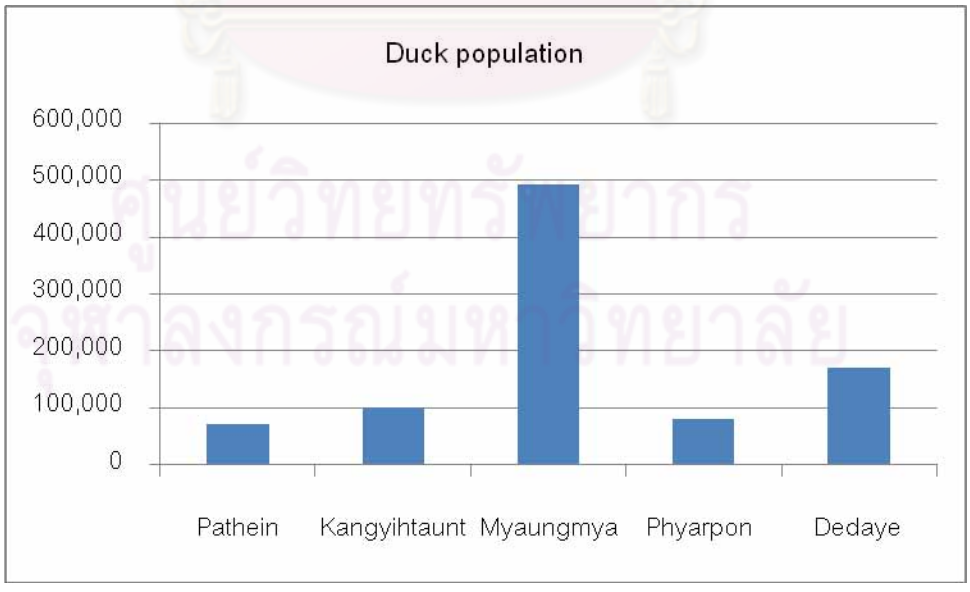

Figure 6 Duck population in study 5 townships, Ayeyarwaddy delta region

1.1.1 Serological status of duck farms in five townships, Ayeyarwaddy delta region

HI results of serum samples and cloacal swabs collected from duck farms in five townships were showed in Table 6. All townships, except Phyarpon township were found HPAI seropositive in ducks. Of these 1,459 serum samples, 156 (10.7%) were detected seropositive. Among 50 farms, 12 (24%) were found seropositive. The virus was not detected from all oropharyngeal swabs.

Table 6 Serological and virus isolation results of HPAI H5N1 in Pathein, Kangyihtaunt, Myaungmya, Phyarpon and Dedaye townships (2009)

Township	No. of Village	No. of farm	No. of HI positive farm	No. of sera tested	No. of HI positive sera	No. of OP swab tested	Virus isolation
Pathein	6	10	5 (50 %)	290	74 (25.5 %)	300	Not detected
Kangyihtaunt	6	10	5 (50 %)	285	64 (22.5 %)	300	Not detected
Myaungmya	8	10	1 (10 %)	285	2 (0.7 %)	300	Not detected
Phyarpon	5	10	-	299	-	300	Not detected
Dedaye	5	10	1 (10 %)	300	16 (5.3%)	300	Not detected
Total	**30**	**50**	**12 (24 %)**	**1459**	**156 (10.7%)**	**1500**	

All townships did not have the history of HPAI outbreaks. The highest seropositivity 74 samples (25.5%) in Pathein township and the second highest seropositivity 64 samples (22.5%) in Kangyihtaunt township were observed (Table 6). At the flock level, the highest seropositivity 5 farms (50%) were detected in Pathein and Kangyihtaunt townships (Table 6). In HI test, seropositive serum samples were defined as HI titers ≥ 1:16. The profile of serological results shows in Figure 7.

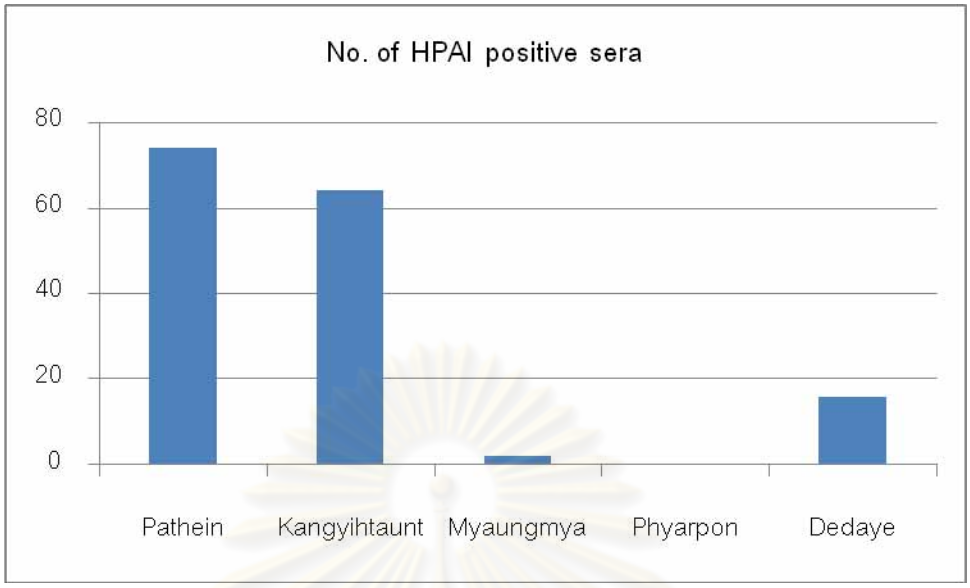

Figure 7 Results of serological profile with the number of HPAI positive sera by detecting antibodies of HPAI H5N1 in five townships (2009)

2.1 Risk factor study in five townships

Study of risk factors was conducted by using case-control study to determine the association of risk factors with HPAI H5N1 seropositive in ducks in five townships, Pathein, Kangyihtaunt, Myaungmya, Phyarpon and Dedaye, Ayeyarwaddy delta region, Myanmar.

Questionnaire data had been collected through personal interview with 50 duck farmers. Case and control groups were selected and classified based on the evidence of HI test positive against HPAI H5N1 antibodies in 2009 ducks cross sectional study. In this study, 12 cases and 38 controls were included and the data from duck farmers collected during 1 April 2010 to 30 June 2010.

All of duck farms were local breed layer type of ducks in both case and control farms. The average number of ducks in case farms was 1,018 ducks. In control farms was approximately 732 ducks. The average age of ducks in case and control farms was 18 and 12 months, respectively.

2.2 Poultry supply chain study in Phyarpon township

The poultry population in Phyarpon township was approximately 0.114 million birds including 61% chickens and 39% ducks (Figure 8), (data source from LBVD Phyarpon, 2010). The poultry population was dropped in Phyarpon after severe cyclone Nargis in 2008. There were 64 commercial duck farms with the population of 31,263 (average-500 ducks/farm) and 19,300 backyard ducks. There were 13 commercial layer farms with the population of 7,369 (average-550 birds/farm) and three commercial broiler farms with the population of 2,450 (average-800 birds/farm).

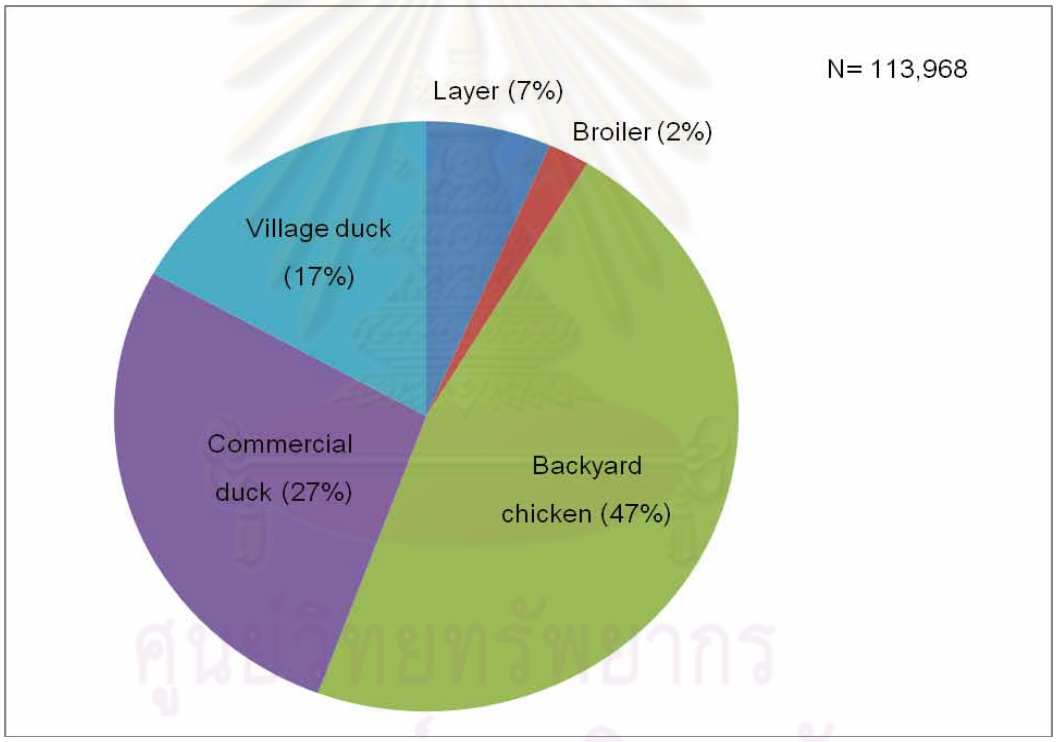

Figure 8 Poultry population in Phyarpon township including ducks, backyard and commercial chickens during 1 April to 30 June 2010

Figure 9 shows the directional flow of imported poultry and poultry products into Phyarpon as well as exported poultry and poultry products from Phyarpon to neighbouring townships or other States or Divisions.

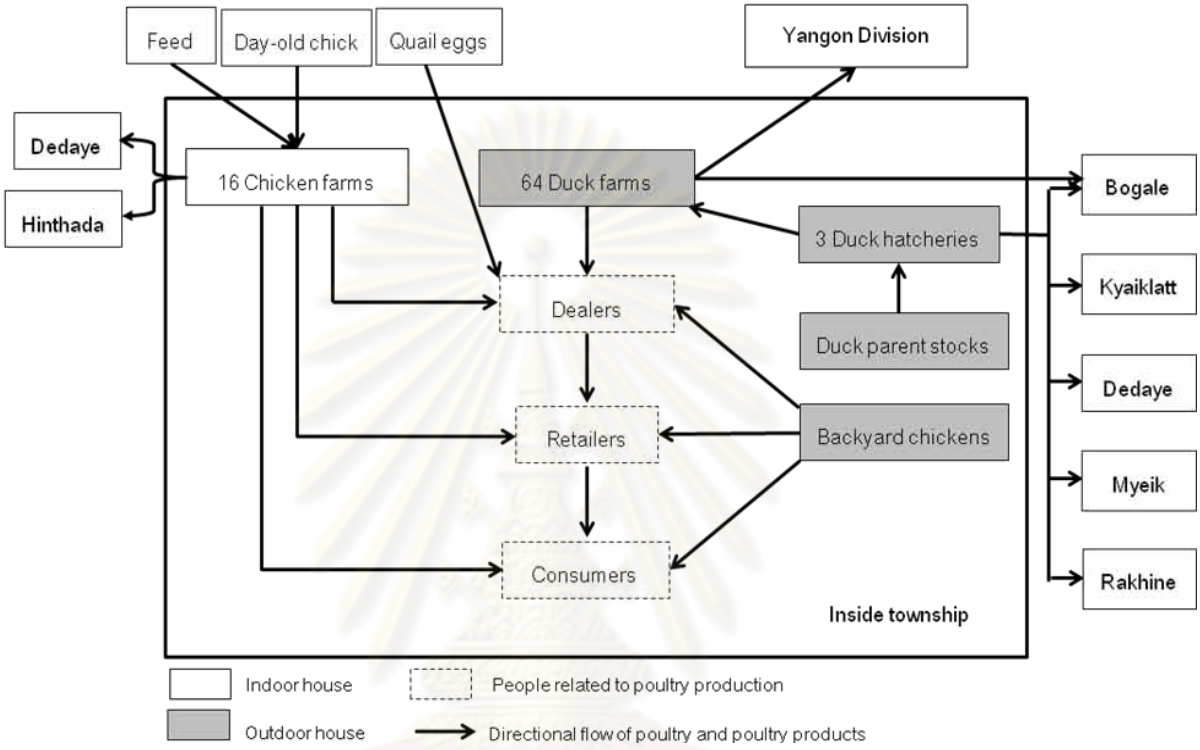

Figure 9 Directional flows of imported and exported poultry and poultry products into and from Phyarpon township

There were three poultry and poultry products such as feed, day-old chicks and quail eggs that supported to Phyarpon from Yangon city (Table 7). Feed for commercial layer and broiler chickens were directly supported from Yangon CP Company with two dealers but amount of feed was low. Most farmers fed their ducks with local feed such as broken rice, prawn meal and water hyacinth. Non-purchased supplemented feed was used for backyard chickens. For commercial chicken raising, day-old chicks were supported from Yangon CP Company but the capacity was very low. There were no quail farms in Phyarpon township. Approximately 200 quail eggs per day were supported from Yangon quail farms to Phyarpon township for consumption.

Table 7 Import of poultry and poultry products to Phyarpon township based on questionnaire during April to June 2010

Items	Origin	Amount	Duration	Transportation	Dealers	Remark
Day-old chicks	Yangon CP	Data not available	Whole year	Boat, car	CP dealer	Stop in studying period
Feed	Yangon CP	Data not available	Whole year	Boat, car	CP dealer	Stop in studying period
Quail eggs	Yangon	200	Whole year	Boat	Dealer	Daily

There were four poultry and poultry products such as day-old ducks, duck eggs, chicken eggs and duck feather that sent to neighbouring townships and other States or Divisions (Table 8).

There were three main duck hatcheries that supported day-old ducks during the hatching season (June to October) approximately 0.336 million for the whole township, neighboring townships and other States or Divisions (data source LBVD, 2009). However, there were no specific parent stocks, the hatchery owners selected the duck farms and then support the male ducks (1 male: 10 female) to selected farms. These duck farms resupplied the fertile eggs to hatcheries with special price that more 15 kyats than the current price 115 kyats. The capacity of these three duck hatcheries was 0.48 million during hatching season. The hatchability was approximately 70% (0.336 million). Among then, male and female day-old duck percentage is nearly the same. These day-old ducks were distributed within township, and neighbouring township such as Bogale, Kyeiklatt and Dedaye, Yangon Division, Tanintharyi Division and Rakhine State (Table 8 and Figure 9).

Commercial duck raising, ducks were set free on the water in canal and in the paddy field for nearly two hours in the morning and return to the farm to have the supplement feed that include broken rice, prawn meal and water hyacinth, as well as in the evening. Normally ducks were laid eggs in the early morning. Point of laying is at five months of duck age. The daily egg production rate was nearly 70% (22,000 eggs) in commercial duck farms and 50% (9,000) in backyard ducks. There were 15 egg dealers in Phyarpon township; eight dealers distributed approximately 19% of duck eggs to retailers in Phyarpon and seven dealers sent approximately 8% to Bogale and 73% to Yangon dealers (Table 8). There were no imported duck eggs from other places to Phyarpon. Some farmers kept their ducks until 2-3 years, after that sold their spent ducks to poultry dealers for meat purpose and to other farmers who continue to keep for raising. Amount of live ducks flow for meat purpose was low during the study period.

The commercial chicken layer and broiler populations were very low approximately 8% of poultry population (Figure 7). The biosecurity level of commercial layer and broiler farms was very low. The daily egg production rate in these commercial layer farms was approximately 80% (5,900 eggs). Approximately 48% of eggs were distributed to Kyeiklatt and Hinthada townships by egg dealers and the left 52% were used within the townships. There were more backyard chickens approximately 47% (53,586 backyard chickens) of poultry population. The backyard chickens were not distributed to other places, used for consumption within township.

There was one duck and chicken feathers collector. Approximately 2600 viss of feather were collected from duck and chicken meat sellers and sent to Yangon, during October to March (data source LBVD, 2009).

Table 8 Export of poultry and poultry products from Phyarpon township to neighbouring townships and other States or Divisions, based on questionnaire during April to June 2010

Items	Origin	Amount	Duration	Transportation	Dealers	Destination	Remark
Day-old ducks	3 hatchery	Data not available	June to October	Boat, car, trishaw	-	Yangon*, Tanintharyi* Rakhine*, Dedaye[a], Bogale[a], Kyeiklatt[a]	Stop in studying period
Duck eggs	64 duck farms	25,000	Whole year	Boat, car, trishaw, motorcycle	Dealers, retailers	Yangon*, Bogale[a]	Daily
Chicken eggs	13 layer farms	3,000	Whole year	Boat, car, trishaw, motorcycle	Dealers, retailers	Hinthada[a], Kyeiklatt[a]	Daily
Duck & chick feather	1 collector	Data not available	October to March	Boat, motorcycle	Dealers	Yangon*	Stop in studying period

*State and Division, [a]Township

Table 9 Distribution of poultry and poultry products within Phyarpon township based on questionnaire during April to June 2010

Items	Origin	Amount	Duration	Transportation	Dealers	Remark
Backyard chickens	villages	1,000	Whole year	Boat, car, bicycle, motorcycle	Village collectors, dealers, retailers	Daily
Live ducks	64 duck farms and villages	200	Whole year	Boat, car	Dealers, retailers	Daily
Day-old ducks	3 hatcheries	Data not available	June to October	Boat, car, trishaw	-	Stop in studying period
Chicken eggs	13 layer farms	2,500	Whole year	Boat, car, trishaw, motorcycle	Dealers, retailers	Daily
Duck eggs	64 duck farms	6,000	Whole year	Boat, car, trishaw, motorcycle	Dealers, retailers	Daily

2.3 Institutional review of Phyarpon township

Livestock Breeding and Veterinary Department of Phyarpon township takes some actions according to Animal Health and Development Law acted on 25th November, 1993 by the State Law and Order Restoration Council.

i) To carry out animal health and development work
ii) To promote livestock development
iii) To prevent outbreak of contagious disease in animal and to control the outbreak systemically when it occurs
iv) To inspect imported animal, animal products and animal feed
v) To issue recommendation certificate concerning animal, animal products and animal feeds for export
vi) To protect animal by law from being ill-treated

For animal movement, most of the farmers and traders are need PC3 (permission certificate 3) from the local veterinary officer who is responsible for monitoring and checking the clinical signs of poultry without taking samples or any testing. For raising of poultry, the farmers are needed to register at Phyarpon LBVD. Activities concern with HPAI prevention and control taking by LBVD of Phyarpon were practically low.

2.4 Epidemiological review of HPAI in Phyarpon township

Myanmar suffered the first wave of HPAI outbreaks in 2006. After the outbreak, LBVD determined the high risk and low risk areas to conduct the regular surveillance activities according to OIE and FAO guidelines. Phyarpon township was defined as high risk area according to the duck populated area, backyard poultry populated area, being small live-bird markets, closeness of wetland and poultry and poultry products movement. The surveillance program in Phyarpon township was conducted since 2007. In 2008 surveillance in ducks, 1% of tested sera was detected HPAI seropositive but virus was not detected.

There is no HPAI outbreak in Phyarpon township. LBVD of Phyarpon township always conducts the active and passive clinical surveillance by round checking (Table 10).

Table 10 Epidemiological review of HPAI surveillance in duck in Phyarpon township from 2006 to May, 2010

Year	2006	2007	2008	2009	May-2010
Serological surveillance	No surveillance	N = 395 Not detected	N = 300 1% of tested duck sera (+)ve	N = 300 Not detected	No surveillance
Virological surveillance	No surveillance	N = 395 Not detected	N = 300 Not detected	N = 300 Not detected	No surveillance
Clinical active & passive surveillance	Yes	Yes	Yes	Yes	Yes

3.1 Risk factors analyses

3.1.1 Univariable analyses

Of the 18 factors were assessed in the univariable analyzes, 12 were met the criteria for selection of multivariable logistic regression model (P-value ≤ 0.25) (Table 11). These were source of ducks, starting of duck's age for raising, time of flock keeping, egg containers, reuse containers, source of feed, source of water, farming system, selling of ducks, person who take care ducks and receiving visitors and relatives to the farm. The remaining six factors were not met for inclusion in the multivariable logistic regression process.

Table 11 Results of univariable analyses of risk factors for highly pathogenic avian influenza (H5N1) virus infection in ducks in Ayeyarwaddy delta region

Variables	Case (n=12), n(%)	Control (n=38), n(%)	OR, 95% CI	P-value
Source of ducks*				
Ayeyarwaddy	7 (58)	37.5 (99)	0.16 (0.08-0.31)	0.00
Bago East & Yangon	5 (42)	0.5 (1)		
No. of ducks in the farms				
< one thousand	10 (83)	32 (84)	0.94 (0.16-5.40)	1.00
> one thousand	2 (17)	6 (16)		
Starting age for raising *				
Day-old ducks	5 (42)	36 (95)	0.04 (0.01-0.25)	0.00
Pullet ducks	7 (58)	2 (5)		
Time of flock keeping *				
> 2 years	6 (50)	10 (26)	2.80 (0.73-10.72)	0.163
< 2 years	6 (50)	28 (74)		

Continue (Table 11)

Variables	Case (n=12), n(%)	Control (n=38), n(%)	OR, 95% CI	P-value
Selling of eggs				
Local market	5 (42)	10 (26)	1.64 (0.42-6.45)	0.496
Dealers	7 (58)	23 (61)		
Egg containers*				
Wooden box	7 (58)	5 (13)	8.12 (1.83-36.00)	0.006
Bamboo basket & Plastic tray	5 (42)	29 (76)		
Reuse containers *				
After cleaning	4 (33)	26 (68)	0.08 (0.02-0.38)	0.001
Without cleaning	8 (67)	4 (11)		
Source of feed *				
Phyarpon District	1 (8)	19 (50)	0.10 (0.01-0.82)	0.016
Pathein & Myaungmya Districts	10 (83)	18 (47)		
Source of water *				
Reservoir	8 (67)	6 (16)	10.67 (2.42-47.0)	0.002
Public well	4 (33)	32 (84)		
Setting of ducks*				
Paddy field	7 (58)	10 (26)	3.92 (1.01-15.21)	0.077
Lake and canal	5 (42)	28 (74)		
Chick & quail farms within 1km radius				
Yes	3 (25)	7 (18)	1.13 (0.23-5.46)	1.00
No	8 (67)	21 (55)		
Contact with wild birds				
Yes	7 (58)	16 (42)	2.77 (0.61-12.51)	0.284
No	3 (25)	19 (50)		

Continue (Table 11)

Variables	Case (n=12), n(%)	Control (n=38), n(%)	OR, 95% CI	P-value
Farming system *				
Free-ranging	3 (25)	22 (58)	0.24 (0.06-1.04)	0.095
Semi-intensive and intensive	9 (75)	16 (42)		
Selling of ducks *				
All in all out	9 (75)	37 (97)	0.08 (0.01-0.87)	0.038
Partially	3 (25)	1 (3)		
Cleaning duck farm				
Yes	4 (33)	9 (24)	1.39 (0.34-5.76)	0.717
No	8 (67)	25 (66)		
Person who take care ducks *				
Labour	6 (50)	9 (24)	3.22 (0.83-12.51)	0.146
Family member	6 (50)	29 (76)		
Receiving visitors and relatives *				
Yes	6 (50)	6 (16)	3.83 (0.90-16.26)	0.128
No	6 (50)	23 (61)		
Rodents				
Yes	6 (50)	26 (68)	0.46 (0.12-1.73)	0.309
No	6 (50)	12 (32)		

***** Variables included in multivariable logistic regression model.

3.1.2 Multivariable analyses

Twelve factors that significant from univariable analyses were subjected for further multivariable analyses. The results of multivariable logistic regression model are shown in Table 12. Three variables were remained in the final model including egg containers and source of water as risk factors, while in reusing container as a protective factor.

Table 12 Results of multivariable logistic regression model for highly pathogenic avian influenza H5N1 in ducks in Ayeyarwaddy delta region

Variables	OR (95% CI)	P-value
Egg containers		
Wooden box	52.66 (2.34-1.188x10^3)	0.013
Bamboo basket and Plastic card		
Reuse containers		
After cleaning	0.026 (0.00-0.42)	0.01
Without cleaning		
Source of water		
Reservoir	30.74 (1.96-481.64)	0.015
Public well		

3.2 Qualitative risk assessment of HPAI in Phyarpon township

The results of release assessment, exposure assessment and consequence assessment of HPAI by qualitatively on poultry and poultry products in Phyarpon township are showed in Table 13. There were 11 factors to consider for the assessment of qualitative risk of HPAI during the study period. Eight factors such as feed, day-old chicks, day-old ducks, quail eggs, chicken eggs, duck eggs, layer and broiler, and duck and chicken feather were estimated the overall risk as negligible with low to moderate uncertainty, while in wild birds was low with moderate uncertainty. However, the overall risk of backyard chickens and ducks were estimated as moderate with low uncertainty.

Table 13 Results of qualitative risk estimation and associated uncertainties for release, exposure and consequence assessment of HPAI on poultry and poultry products in Phyarpon township

Factors	Release		Exposure & Consequence		Overall risk	
	Risk	Uncertainty	Risk	Uncertainty	Risk	Uncertainty
Feed*	Negligible	Moderate	-	-	Negligible	Moderate
Day-old chicks*	Negligible	Moderate	-	-	Negligible	Moderate
Day-old ducks*	Negligible	Moderate	-	-	Negligible	Moderate
Quail eggs*	Negligible	Low	-	-	Negligible	Low
Chicken eggs*	Negligible	Moderate	-	-	Negligible	Moderate
Duck eggs*	Negligible	Moderate	-	-	Negligible	Moderate
Layer & broiler*	Negligible	Moderate	-	-	Negligible	Moderate
Duck and chick feather	Low	High	Negligible	Moderate	Negligible	Moderate
Wild birds	Low	Moderate	Moderate	Moderate	Low	Moderate
Backyard chickens	Moderate	Moderate	Moderate	Low	Moderate	Low
Live ducks	Moderate	Moderate	Moderate	Low	Moderate	Low

*If the result is negligible in release assessment, this factor is not considered for exposure and consequences assessment

3.2.1 Feed

Release assessment

The amount of feed that brought into Phyarpon township was considerably low. Most of the farmers fed their domestic ducks and backyard chickens with by-horticultural products such as broken rice, prawn meal and water hyacinth. For commercial layer and broiler chickens, the frequency of commercial feed purchase from Yangon CP Company was varied. A large amount of commercial feed were brought and stored in a closed container for such long time period. At the time of study period, there was no imported feed into Phyarpon township. The risk for the introduction of HPAI virus through feed that entered Phyarpon township was estimated as negligible with moderate uncertainty.

Exposure assessment

The exposure assessment of HPAI for feed was not assessed as the release assessment was estimated as negligible.

3.2.2 Day-old chicks

Release assessment

For commercial layer and broiler chickens raising, day-old chicks were provided from Yangon CP Company. Commercially produced day-old chicks are unlikely to be infected with HPAI virus when they leave from the incubator given properly management (Sims and Brown, 2008). However, there is no experimental studies have been conducted using eggs contaminated or infected with HPAI virus to prove this and therefore this possibility cannot be ruled out (Brugh and Johnson, 1986). If day-old chicks are spreading diseases, this is more likely to be via contact with contaminated transport containers or through exposure to infection after hatching. This could be facilitated by management practice in cleaning containers. The capacity of day-old chicks supported to Phyarpon township was very low. During the study period, there were no imported day-old chicks to

Phyarpon. The estimated risk for the introduction of HPAI virus through the day-old chicks into Phyarpon township was negligible with moderate uncertainty.

Exposure assessment

As the release assessment of HPAI for day-old chicks was estimated as negligible, the exposure assessment was not assessed.

3.2.3 Day-old ducks

Release assessment

In Phyarpon township, most of the duck farmers raised ducks that hatched from the three hatcheries. There were no special duck parent stocks for these hatcheries. The hatchery owners selected the duck farms and then supported the male ducks to selected farms. These duck farms resupplied the fertile eggs to hatcheries. The day-old ducks were enough for being raised in the township. There were no imported day-old ducks from the previous outbreak areas and recently ducks seropositive areas. One percent of seropositive in ducks was occurred but no virus detected in 2008 surveillance. In 2009 surveillance, no seropositive ducks were detected (Table 6). However, no studies have been published on the effect of maternal antibody to H5 avian influenza viruses on infection and virus excretion in day-old duckling. Therefore, the risk estimated for release and introduction of HPAI virus into Phyarpon township through day-old ducks was negligible with moderate uncertainty.

Exposure assessment

The estimated risk of HPAI for day-old ducks was negligible, therefore, further exposure assessment of HPAI was not considered.

3.2.4 Quail eggs

Release assessment

A little amount of quail eggs was supported to Phyarpon township by one dealer from Yangon. There was no quail farm in the study area. Experimentally, quail are highly susceptible to infection with HPAI virus (Perkins and Swayne, 2001). The risk for the release and introduction HPAI virus into Phyarpon township through the quail eggs was negligible with moderate uncertainty.

Exposure assessment

The release assessment of HPAI for quail eggs was estimated as negligible, therefore the exposure assessment was not considered.

3.2.5 Chicken eggs

Release assessment

Chicken eggs were supported from 13 layer farms which have low biosecurity. These eggs were not cleaned before being distributed to egg dealers and sellers. HPAI virus could potentially contain on the surface of eggs that produced from the infected hens but the clinical course of HPAI in chickens is extremely short. It was unlikely that infected eggs enter the market chain. The contaminations of eggs with HPAI virus and probability of survival on egg shell are very low. There were not imported chicken eggs from the previous outbreak areas. Therefore, the estimated risk for release and introduction of HPAI virus through the chicken eggs into Phyarpon township was negligible with moderate uncertainty.

Exposure assessment

The release assessment of HPAI for chicken eggs was estimated as negligible, therefore the exposure assessment was not considered.

3.2.6 Duck eggs

Release assessment

Duck eggs were supported by commercial and backyard duck farmers for demand of markets. Most of the duck farmers were not washed and cleaned the surface of duck eggs. No studies have been conducted on the presence of Asian-lineage H5N1 HPAI viruses in eggs from infected ducks but, based on experience with other species; egg laid by infected ducks could potentially contain some virus (Promkuntod et al., 2006). The surface of duck eggs is frequently soiled with faces and since ducks can be subclinically infected and pass virus in faces, contaminated eggs pose a potential transmission of risk. There were no supported duck eggs from the previous outbreak areas and recently ducks seropositive areas. The estimation of risk for release and introduction of HPAI virus through the duck eggs into Phyarpon township was negligible with moderate uncertainty.

Exposure assessment

The release assessment of HPAI through the duck eggs was estimated as negligible, the exposure assessment of HPAI related with duck eggs was not assessed.

3.2.7 Commercial layer and broiler chickens

Release assessment

There were 13 layer and three broiler chicken farms, approximately 8% of total population, with low biosecurity level. All of these farms are situated in segregated area from duck farms. It was not used mix raising system. Disinfection and lime are used before entering the farms. People who worked with chickens changed their shoes before entering the farms. All farms have net to prevent entering wild and resident birds. There was no outbreak information and the history of HPAI seropositive in commercial chickens in Phyarpon township. Therefore, the estimation of risk for release and introduction of HPAI

virus through commercial chickens into Phyarpon township was negligible with moderate uncertainty.

Exposure assessment

As the results of negligible for introduction of HPAI through the commercial layer and broiler chickens, the exposure assessment was not considered.

3.2.8 Duck and chicken feather

Release assessment

Duck and chicken feather collector collected the feather from chicken and duck meat sellers during October to March. It is proved that the affected feather can cause infection in orally inoculated domestic ducks (Yamamoto et al., 2007). HPAI H5N1 virus can replicate in feather epidermal cells in asymptomatic domestic ducks (Yamamoto et al., 2008). At the time of studying period, collection of feather was stopped because of raining season. The estimated risk for release and introduction of HPAI virus through the duck and chicken feather into Phyarpon township was low with high uncertainty.

Exposure assessment

The collector delivered these feathers to Yangon by boat, two to three times during the collection period. These feathers were dry and stored for certain period. The estimated risk for exposure and transmission of HPAI virus through the duck and chicken feather within Phyarpon township was negligible with moderate uncertainty.

3.2.9 Wild birds

Release assessment

The species and presence of wild birds observed in Phyarpon township were based on data collected by showing the pamphlet of highly pathogenic avian influenza in wild bird species that published by the organization of FAO and LBVD, during questionnaire interview (Table 14). Most of these observed wild birds can carry or excrete HPAI virus. Since, the majority of Phyarpon township located in low land, wild birds were frequently found. There was no surveillance of HPAI in wild birds and no outbreaks information in wild birds in Phyarpon township. The frequency of wild birds' presence in Phyarpon township was high; the likelihood of those wild birds being infected with HPAI virus was not clear. The probability of likelihood of release and introduction of HPAI virus into Phyarpon township was low with moderate uncertainty.

Exposure assessment

Most of domestic duck farms were located in paddy field. These ducks were the most likely to have direct and indirect contact with wild birds which shared their habitat with domestic ducks in paddy fields and wetland. This provided an opportunity for an exchange of viruses between these two populations. The probability of likelihood of exposure and transmission of HPAI virus to domestic poultry within Phyarpon township through the infected wild birds was moderate with low uncertainty.

Table 14 List of birds species observed in Phyarpon township

Order	Common name	Scientific name	Report of HPAI
Anseriformes	Lesser whistling duck	*Dendrocygna javanica*	(Photieng and Jamjomroon, 2006)
	Ruddy shelduck	*Tadorna ferruginea*	(Kwon et al., 2010)
Gruiformes	Common moorhen	*Gallinula chloropus*	-
	Purple swamphen	*Porphyrio porphyrio*	-
	Sarus Cranes	*Grus antigone*	-
Charadriiformes	Gull	*Larus canus*	(Brown et al., 2008)
	Sand piper	*Ctitis hypoleucos*	-
	Lapwing	*Vanellus vanellus*	-
Ciconiiformes	Painted storks	*Mycteria leucocephala*	-
	Herons	*Ardea herodias*	(Ellis et al., 2004)
	Egrets	*Ardea alba*	(Ellis et al., 2004)
Passeriformes	House crow	*Corvus splendens*	(Nishiguchi et al., 2005)
	Common myna	*Acridotheres tristis*	(Photieng and Jamjomroon, 2006)
	House sparrow	*Passer domesticus*	(Boon et al., 2007)
Pelecaniformes	Cormorant	*Phalacrocorax carbo*	Pothieng and Jamjomroon 2006
Falconiformes	Shikra	*Accipiter badius*	-
	Kite	-	-
Columbiformes	Rock pigeon	*Columba livia*	(Photieng and Jamjomroon, 2006)
	Dove	*Streptopelia chinensis*	-

3.2.10 Backyard chickens

Release assessment

Backyard chickens raised in Phyarpon are being free-ranging and some are mixed with ducks and geese. Geospatial analyses of HPAI outbreaks in Thailand showed that the spatial distribution of HPAI outbreaks in chicken and ducks is strongly associated with that of free-grazing ducks (Gilbert et al., 2006). Most of rural households have backyard chickens that may expose to other residents birds and wild birds. Moreover, the absence of fences or other barriers, these chickens roamed freely around the property. Biosecurity level and environmental condition and lack of hygiene measures are favored to the introduction of HPAI virus into backyard chickens. It is reported that outbreaks of HPAI in backyard chickens in Myanmar ((Mon et al., 2008b). The estimated risk for release and introduction of HPAI virus through the backyard chickens into Phyarpon township was moderate with moderate uncertainty.

Exposure assessment

The movements of backyard chickens were only within the township's markets. Bamboo baskets were mainly used for carrying of backyard chickens and some carried by hand. Most of dealers never cleaned these containers. Most of the meat sellers made dressing the backyard chickens inside the market and at home, and throw the feathers and the waste products into the seawage and dustbin. This behavior is higher chance for transmission of HPAI virus to commercial layer and broiler chicken farms. Moreover, the absence of fences or barriers, it is a good condition to get exposure of HPAI virus. The estimated risk for exposure and transmission of HPAI virus through the backyard chickens within Phyarpon township and neighbouring townships or States and Divisions was moderate with moderate uncertainty.

3.2.11 Free-ranging ducks

Release assessment

Most of the duck farms with less of biosecurity level were located in the rice fields which were favored habitat for wild birds. Some were mixed farming system with backyard chickens, geese and pigs. The paddy field, small river split from Ayeyarwaddy river and canal were used as a duck grazing area. In 2008 surveillance, 1% HPAI seropositive was found in ducks but in 2009, no seropositive was detected (Table 6). The virus also was not detected. It is well known that duck is one of the aquatic birds that act as a reservoir for HPAI H5N1 virus if they do not exhibit clinical signs. Subclinically infected ducks do not shed large amounts of virus into the environment. However, if they show clinical sign, the amount of virus shedding is increased (Tumpey et al., 2002). The estimated risk for release and introduction of HPAI virus through the free-ranging ducks into Phyarpon township was moderate with moderate uncertainty.

Exposure assessment

The free-ranging duck husbandry had a high possibility to play an important role in spreading influenza virus because of movement of ducks and healthy reservoir for HPAI virus H5N1. Spent ducks and pullet ducks were not distributed to other neighbouring townships and States or Divisions; a little mount of duck was selling within township during the study period. Most of meat sellers dressed the ducks at the shop in market and at home. The duck feathers were collected by the feather collectors but waste products were discarded into dustbin and drainage. This practice is more risk for the exposure of HPAI virus to commercial layer and broiler chickens. The estimated risk for exposure and transmission of HPAI virus through the free-graining ducks within Phyarpon township and neighbouring townships or States and Divisions was moderate with moderate uncertainty.

3.2.12 Consequence assessment of HPAI outbreaks

When HPAI outbreaks occur in domestic poultry in Phyarpon township, various control measures and actions are implemented by LBVD of Phyarpon. The magnitude of impact would be effect to the economic of chicken and duck farmers and to human health especially duck workers, farmers, dealers, sellers and consumers. When HPAI outbreaks occur, LBVD of Phyarpon will implement various control measures organizing with head quarter of LBVD. The outbreaks can be control within the affected location through the movement restriction. The economic impact has to reduce by compartmentalizing the affected farms. If the HPAI outbreak occurs, compensation should be considered to pay for farmers; otherwise we can not available outbreak information. Moreover, a huge drop in market demand can be found for consumer safety as well as market price. This will lead to further loss of income for poultry farmers, dealers and retailers. Not only these effects, public health, social and environmental effects can be resulted from HPAI outbreaks. Therefore the estimated risk for consequence and impact of HPAI outbreak through the infected domestic poultry within Phyarpon township and other townships or States and Divisions was moderate with low uncertainty.

CHAPTER V

DISCUSSION

Four distinct HPAI epidemic waves were recorded in Myanmar during 2006 to 2010 causing approximately one million birds' death and one non-fatal human case. The outbreaks were occurred in Sagaing, Mandalay, Yangon and Bago Divisions as well as Mon and Eastern Shan States. Geographically, most of the outbreaks took place in central Myanmar. Affected bird species are commercial layer, backyard chickens, quails and guinea fowl. In response to HPAI outbreaks, LBVD implemented containment measures including stamping-out policy, quarantine and movement restriction, zoning and compartmentalization, hygienic measures, tracing and post-outbreak surveillance according to the 2006 and 2007 contingency plan. The consequence of these outbreaks relate to the direct impact of economic losses and public health intervention. However, it is still need the information of risk of HPAI in Myanmar. This study was aimed to identify the risk factors in ducks farms and to assess the area risk of HPAI on poultry and poultry products to provide risk management and recommendation for HPAI prevention and control in Myanmar. The results of this study show that some critical factors including wooden box-egg container and source of drinking water are associated with being HPAI seropositivity in ducks, while in reuse container after cleaning is associated as a protective factor. The results of the overall risk estimation show that the risk of ducks and backyard chickens were moderate with low uncertainty, while overall risk for wild birds was low with moderate uncertainty. The estimated risk for feed, day-old chicks, commercial layer and broiler chickens, chicken eggs, quail eggs, day-old ducks, duck eggs and duck and chicken feather were negligible with varying levels of uncertainty.

5.1 Serological status of HPAI in duck farms in five townships, Ayeyarwaddy delta region

Free-living bird species such as ducks, geese, swans, gulls, terns and shore birds have been considered as the natural reservoirs for avian influenza viruses (Swayne and Halvorson, 2003). The serological surveillance results have showed seropositivity in ducks from four townships out of five townships in Ayeyarwaddy delta region ranging from zero to 24% at farm level and from zero to 10.7 % at individual level. All of these ducks were healthy at the time of sampling. The highest seropositivity was occurred in Pathein (25.5%) and Kangyihtaunt townships (22.5%). It is interesting that these two townships have no duck hatcheries. Most of the farmers order the ducks from the Bago and Yangon Division (H5N1 outbreak areas) where the 2nd wave of HPAI outbreaks occurred. Therefore, it is more likely, the ducks raised in these townships could get exposure of virus from the previous outbreak areas. In the other two townships, Dedaye and Myaungmya were found seropositive ducks with low positivity (5.3% and 0.7%). These two townships, like Pathein and Kangyihtaunt, are heavy ducks raising areas. The reasons for seropositivity are lower than Pathein and Kangyihtaunt townships, and the likely source of exposures were not clear. In Phyarpon township, unlike other townships, no seropositive ducks were observed. In fact, there are three duck hatcheries in the Phyarpon township and no supported day-old ducks and pullet ducks from other areas where previous HPAI outbreaks or history of HPAI seropositive in ducks.

In this study, the virus was not detected from all oropharyngeal swabs of the seropositive and seronegative ducks. It is likely that at the time of sampling the ducks might not be shedding the virus. All ducks are healthy at the time of sampling, may be carrying low pathogenic or high pathogenic strains of avian influenza. As Ayeyarwaddy delta region is rice growing delta area, the paddy fields are used as feeding grounds of ducks. There was a report of strong association between H5N1 virus and free-grazing duck in the paddy field and it was a critical factor for the persistence and spread of HPAI virus (Gilbert et al., 2006).

5.2 Risk factors of HPAI being seropositive in ducks in five townships, Ayeyarwaddy delta region

In this study there was an association between certain risk factors and being seropositivity of HPAI H5N1 virus in ducks. Using wooden box-egg containers is significantly associated with being HPAI seropositivity in ducks (Odds ratio [OR] 52.66, 95% confidence interval [CI] 2.34-1.188x10^3, P=0.013) compare with bamboo basket and plastic card-egg containers. It is also noted that egg trays and vehicles form the markets are potential sources of infection to poultry (Biswas et al., 2008). It is possible that these egg trays can get contamination with HPAI virus via feces and environment. The types of egg tray used in these study areas are wooden boxes, bamboo baskets and plastic cards. Wooden box-egg containers are difficult to clean. Therefore, it is possible reason to pose high contamination of HPAI virus. Most of the farmers usually share of the egg trays at the dealer shops. Sharing of egg tray is a higher chance of getting HPAI infection in poultry. It is also reported that the discriminate usage of egg trays by egg dealers who used their trays between states and farms is higher risk of infection (Bello et al., 2008).

Reused egg containers after cleaning are negatively associated with being HPAI seropositivity in ducks comparing with without cleaning the containers (OR=0.03, 95% CI=0.00-0.42, P= 0.01). Two types of egg trays as wooden box and bamboo basket are still difficult to conduct appropriate cleaning. The report in the Republic of Korea on the outbreaks of HPAI (H5N1) similarly showed that reuse of egg trays without cleaning is hampered the prevention and control of disease (Wee et al., 2006). It is to be sure that the farmers need to clean and disinfect egg trays before entering or prior to use on the farms. There have been reported that some outbreaks and spreading of avian influenza have been associated with transfer of virus by carrying egg trays (Thomas et al., 2005). However, the equipment used after cleaning, exposing sunlight, dryness and heat, the virus contaminations are less likely.

The water from canal and small river that used as drinking water for ducks showed significant association being of HPAI seropositivity in ducks comparing with the water in public well (OR= 30.739, 95% CI=1.96-481.637, P=0.015). Water is considered as a potential spread of HPAI, it has been contaminated with HPAI virus. Ayeyarwaddy delta region is a water flooded area in the rainy season. There are three seasons including summer, rainy and winner with average temperature of 25° C in this delta region. The annual rain fall is approximately 127 inches. There are a lot of small rivers and canals that split from Ayeyarwaddy river. Infected wild birds and ducks may excrete or transfer HPAI virus to wetland, canal and pond. It is reported that HPAI virus can survive three days in paddy field water at 25-32° C (Songserm et al., 2006b) and longer in cooler condition (Brown et al., 2007). Most of the duck farms in the study area use water from the canal, river and pond as well as set the ducks on the water in the canal, paddy field and river.

Ducks raising system in the study area of Ayeyarwaddy delta region are based on open house system. In this system, ducks are set free on the water in canal and in the paddy field in the morning and return to the farm at noon to have the supplement feed. In the evening, duck farmers pick up the ducks again to the field for natural feed and return in the late evening. This open duck raising system has higher chance for HPAI infection but we found that it was not significant. In Thailand, H5N1 infection was detected in three duck raising systems such as open houses, free-ranging (grazing) ducks and backyard system (Songserm et al., 2006c).

In this study, the results of 95% confidence interval were showed that a wide range, especially in wooden box-egg container (2.34-1.188x10^3) and using source of water from wetland (1.96-481.64). Generally, it may be the effect of small sample size in case and control study. This case-control studies are more likely to have selection bias than other epidemiologic studies (Geneletti et al., 2009). In this study, case and control duck farms classification was based on selection criteria of seropositive and seronegative results of

HPAI in ducks to eliminate selection bias. However, we were not sure for recall bias that based on farmer ability to recall their memories on the past.

Nevertheless, this study did not find a significant association between HPAI seropositivity in ducks and paddy field, receiving visitors, contact wild birds. These factors could be potential risk factors for HPAI infection (Gilbert et al., 2006; Henning et al., 2009b; Fasina et al., 2011). The reason is the limitations of small sample size for case (12 farms) and control (38 farms). Data was not available from some questions to be considered for risk factors.

5.3 Poultry supply chain of Phyarpon township

Poultry supply chain results demonstrated that three connections including within township, exported and imported poultry and poultry products. Within the township, the poultry supply chain is mainly connected with 4 markets that sold poultry and poultry products. Backyard chicken and duck flows are mainly found within the township as well as day-old ducks, duck and chicken eggs. Through our study, the supply chain of poultry and poultry products in Phyarpon township is not complicated.

We found that poultry and poultry products are mostly exported to neighboring townships and other States or Divisions, while in imported poultry and poultry products to Phyarpon are only from Yangon city. We found that approximately 25,000 duck eggs are traded to Yangon city and Bogale township daily. Approximately 3,000 chicken eggs are delivered to neighbouring townships, Hinthada and Kyeiklatt in daily. There are three duck hatcheries that supported the day-old ducks to neighbouring townships including Dedaye, Bogale, and Kyeiklatt and Yangon city, Tanintharyi Division and Rakhine State. This supporting is a wide spreading as a whole region of lower Myanmar. At the time of study period, the hatching of day-old ducks did not start (hatching season June to October). The highlight is the duck feather from Phyarpon that are treaded to Yangon city during October

to March but data not available. It is surprise that the flow of ducks and backyard chickens to neighbouring townships are not found at the study period.

We also found that day-old chicks, feed and quail eggs are supported to Phyarpon from Yangon city. There is no quail farm in Phyarpon. Quail eggs are imported from Yangon city. At the study period, the flow of day-old chicks and feed are stopped for a while. Most of the poultry and poultry movement occur via dealers on boats, trucks and motorcycle. There have been reported that movement of live birds, contaminated transport vehicles and materials increase the chance of HPAI virus spread to poultry (Thomas et al., 2005; Kung et al., 2007; Biswas et al., 2008). Understanding the movement of poultry and poultry products, it is essential to develop the targeted surveillance and appropriate control program of HPAI.

5.4 Qualitative risk assessment of HPAI in Phyarpon township

The overall risk estimation of release assessment, exposure assessment and consequences assessment of HPAI for live ducks and backyard chickens are moderate with low uncertainty, while in case of wild birds is low with moderate uncertainty. The risk estimation for feed, day-old chicks, commercial layer and broiler chickens, chicken eggs, quail eggs, day-old ducks, duck eggs and duck and chicken feather are negligible with varying levels of uncertainty.

The estimated risk for live ducks and backyard chickens are moderate with low uncertainty, which means the occurrence of risk is likely with strong evidence. In case of wild birds, the risk estimation is low with moderate uncertainty which means the occurrence of risk is unlikely with small evidence. The estimated risk for feed, day-old chicks, commercial layer and broiler chickens, chicken eggs, quail eggs, day-old ducks, duck eggs and duck and chicken feather are negligible with varying levels of uncertainty, which means the risk is not occur but cannot be excluded.

As Phyarpon township is rice growing delta area and a lot of surface water, small river and canal split from Ayeyarwaddy river. Water birds and wild birds can contact with ducks in the paddy field. Therefore, free-grazing ducks have a higher chance for contamination HPAI virus. In this risk assessment, most of the estimates were associated with low to high uncertainly and needed to be interpreted with caution. For estimating risk level was combined with epidemiology reviews, information of poultry and poultry products supply chain and existing published literatures but scientific evidence is lacking. Through qualitative risk assessment for the introduction, transmission and impact of HPAI virus in poultry in Phyarpon township was negligible to moderate with low to high level of uncertainty during the study period of April-June 2010.

The high level of uncertainty associated with risk estimation is pointed to significant gaps in knowledge of the epidemiology of HPAI and poultry supply chain. Therefore, extreme cautions are required in the interpretation of the risk estimate. It is needed for the targeted data collection to fulfill some of the relevant knowledge gaps. These targeted areas should be to do survey for the information of the prevalence of HPAI in ducks, wild and resident birds, and backyard chickens.

The risk assessment undertaken in this study were based on the release, exposure and consequence assessment by supporting information of poultry supply chain study, institutional and epidemiological reviewing. From the release and exposure assessment which did not cover all possible introduction and transmission pathways for HPAI virus. The complete introduction and transmission of HPAI would include both direct and indirect ways including environmental temperature, humidity and geographical region and biological factors. Movement of ducks and backyard chickens are considered to play in critical role of spreading of infection. The consequence assessment was considered the impact of HPAI outbreaks, if outbreaks could occur in poultry in Phyarpon township. The qualitative risk assessment conducted on the current study found that overall risk estimation of ducks and backyard chickens were moderate for getting HPAI infection and transmission. In contract,

the qualitative risk assessment done in Thailand reported that the risk of free-ranging ducks was negligible and for live poultry was very low. However, this qualitative risk assessment focused on poultry and poultry products, instead of specific species in Phyarpon township. This qualitative risk assessment were estimated based on outcomes of sero-surveillance of HPAI in ducks and HPAI disease situation, the information of surveillance on other species were not included. The estimation consequently needed to be interpreted carefully based on specific criteria. Risk assessment is a tool to provide information for risk management, in this study the management should be targeted free-grazing ducks and backyard chickens sectors. In meantime, the cross-border trade measures should paid attention in cases of seropositive and new outbreaks in poultry in neighboring townships.

5.5 Conclusions and suggestions

This study was conducted to identify the risk factor in ducks farms in five townships by case-control study with questionnaire interview. The results showed that:

- Wooden box-egg container and source of water from wetland were major risk factors for being HPAI seropositive in ducks.
- Reuse container with cleaning resulted that as a protective factor for being HPAI seropositive in ducks.
- Further studies are necessary to extend the risk factors study in ducks populated areas like Ayeyarwaddy delta region in Myanmar.

This study also conducted qualitative risk assessment of HPAI in poultry in Phyarpon township, Ayeyarwaddy delta region by evaluating the information of poultry supply chain study, relevant institutional and epidemiological review of AI in township. The results showed that:

- Overall risk estimation for backyard chickens and ducks were moderate with low uncertainty.
- Overall risk for wild birds was estimated as low with moderate uncertainty.

- Overall risk estimation for feed, day-old chicks, commercial layer and broiler chickens, chicken eggs, quail eggs, day-old ducks, duck eggs and duck feather were negligible with varying levels of uncertainty.

Suggestion for risk management of HPAI prevention and control are:

- Encourage to farmers for farm registration
- Movement control for free-grazing ducks within village
- Local veterinarian should have sampling and testing program on animal movement at the time of selling of poultry
- Use net or simple pen for backyard chickens
- Improve biosecurity for commercial chickens
- Training and public awareness program for HPAI prevention and control for poultry farmers

REFERENCES

Abdel-Ghafar, A.N., Chotpitayasunondh, T., Gao, Z., Hayden, F.G., Nguyen, D.H., de Jong, M.D., Naghdaliyev, A., Peiris, J.S., Shindo, N., Soeroso, S. and Uyeki, T.M. 2008. Update on avian influenza A (H5N1) virus infection in humans. N. Engl. J. Med. 358(3): 261-273.

Alexander, D.J. 2007. Summary of avian influenza activity in Europe, Asia, Africa, and Australasia, 2002-2006. Avian Dis. 51(1 Suppl): 161-166.

Amonsin, A., Chutinimitkul, S., Pariyothorn, N., Songserm, T., Damrongwantanapokin, S., Puranaveja, S., Jam-On, R., Sae-Heng, N., Payungporn, S., Theamboonlers, A., Chaisingh, A., Tantilertcharoen, R., Suradhat, S., Thanawongnuwech, R. and Poovorawan, Y. 2006. Genetic characterization of influenza A viruses (H5N1) isolated from 3rd wave of Thailand AI outbreaks. Virus Res. 122(1-2): 194-199.

Ardans, A.A. and MacLachlan, N.J. 2004. Orthomyxoviridae and Bunyaviridae, Veterinary Microbiology, 2nd Edition, Blackwell Publishers. 361-367.

Bedford, T. and Cooke, R.T. 2001. Probabilistic Risk Analysis. Foundations and Methods, Cambridge University Press.17-35.

Bello, M., Lukshi, B.M. and Sanusi, M. 2008. Outbreaks of highly pathogenic avian influenza (H5N1) in Bauchi state, Nigeria. Int. J. Poult. Sci. 7(5): 450-456.

Biswas, P.K., Christensen, J.P., Ahmed, S.S., Barua, H., Das, A., Rahman, M.H., Giasuddin, M., Hannan, A.S., Habib, M.A., Ahad, A., Rahman, A.S., Faruque, R. and Debnath, N.C. 2008. Avian influenza outbreaks in chickens, Bangladesh. Emerg. Infect. Dis. 14(12): 1909-1912.

Biswas, P.K., Christensen, J.P., Ahmed, S.S., Das, A., Rahman, M.H., Barua, H., Giasuddin, M., Hannan, A.S., Habib, M.A. and Debnath, N.C. 2009. Risk for infection with highly pathogenic avian influenza virus (H5N1) in backyard chickens, Bangladesh. Emerg. Infect. Dis. 15(12): 1931-1936.

Boender, G.J., Hagenaars, T.J., Bouma, A., Nodelijk, G., Elbers, A.R., de Jong, M.C. and van Boven, M. 2007. Risk maps for the spread of highly pathogenic avian influenza

in poultry. PLoS Comput. Biol. 3(4): 0704-0712.

Boon, A.C., Sandbulte, M.R., Seiler, P., Webby, R.J., Songserm, T., Guan, Y. and Webster, R.G. 2007. Role of terrestrial wild birds in ecology of influenza A virus (H5N1). Emerg. Infect. Dis. 13(11): 1720-1724.

Brown, J.D., Stallknecht, D.E. and Swayne, D.E. 2008. Experimental infections of herring gulls (Larus argentatus) with H5N1 highly pathogenic avian influenza viruses by intranasal inoculation of virus and ingestion of virus-infected chicken meat. Avian Pathology. 37(4): 393-397.

Brown, J.D., Swayne, D.E., Cooper, R.J., Burns, R.E. and Stallknecht, D.E. 2007. Persistence of H5 and H7 avian influenza viruses in water. Avian Dis. 51(1 Suppl): 285-289.

Brugh, M. and Johnson, D.C. 1986. Epidemiology of avian influenza in domestic poultry. In proceedings 2nd International Symposium on Avian Influenza.177-185.

Burgos , S. and Burgos, S.A. 2007. Influenza A viruses in poultry. A condensed rev. Int. J. Poult. Sci. 6(10): 705-708.

Capua, I. and Marangon, S. 2006. Control of avian influenza in poultry. Emerg. Infect. Dis. 12(9): 1319-1324.

Easterday, B.C., Hinshaw, V.S. and Halvorson, D.A. 1997. Influenza. In: Calnek, B.W. (Ed.), Diseases of Poultry.10th ed. Iowa State University Press, Ames, Iowa. 583–605.

EFSA. 2006. Scientific report on migratory birds and their possible role in the spread of highly pathogenic avian influenza. European Food Safety Authority-EFSA-Q-2005-243.

Ellis, T.M., Bousfield, R.B., Bissett, L.A., Dyrting, K.C., Luk, G.S., Tsim, S.T., Sturm-Ramirez, K., Webster, R.G., Guan, Y. and Malik Peiris, J.S. 2004. Investigation of outbreaks of highly pathogenic H5N1 avian influenza in waterfowl and wild birds in Hong Kong in late 2002. Avian Pathology. 33(5): 492-505.

FAO. 2004. Guideline principles for highly pathogenic avian influenza surveillance and diagnostic networks in Asia. FAO expert meeting, Bangkok, Thailand, 21-23 July 2004.

FAO EMPRES. 2010. H5N1 HPAI Global Overview, September and October 2010. (25): 1-8.

Fasina, F.O., Rivas, A.L., Bisschop, S.P., Stegeman, A.J. and Hernandez, J.A. 2011. Identification of risk factors associated with highly pathogenic avian influenza H5N1 virus infection in poultry farms, in Nigeria during the epidemic of 2006-2007. Prev. Vet. Med. 98(2-3): 204-208.

Geneletti, S., Richardson, S. and Best, N. 2009. Adjusting for selection bias in retrospective, case-control studies. Biostatistics. 10(1): 17-31.

Gilbert, M., Chaitaweesub, P., Parakamawongsa, T., Premashthira, S., Tiensin, T., Kalpravidh, W., Wagner, H. and Slingenbergh, J. 2006. Free-grazing ducks and highly pathogenic avian influenza, Thailand. Emerg. Infect. Dis. 12(2): 227-234.

Henning, J., Pfeiffer, D.U. and Vu le, T. 2009a. Risk factors and characteristics of H5N1 Highly Pathogenic Avian Influenza (HPAI) post-vaccination outbreaks. Vet. Res. 40(3): 15.

Henning, K.A., Henning, J., Morton, J., Long, N.T., Ha, N.T. and Meers, J. 2009b. Farm- and flock-level risk factors associated with Highly Pathogenic Avian Influenza outbreaks on small holder duck and chicken farms in the Mekong Delta of Viet Nam. Prev. Vet. Med. 91(2-4): 179-188.

Hinshaw, V.S., Webster, R.G. and Turner, B. 1980. The perpetuation of orthomyxoviruses and paramyxoviruses in Canadian waterfowl. Can. J. Microbiol. 26(5): 622-629.

Jing, L., Jing-fei, W., Chun-yan, W., Yan-tao, Y., Zeng-tao, J. and Hong-bin, W. 2007. Establishment of a risk assessment framework for analysis of the spread of highly pathogenic avian influenza. Agri. Sci. 6(7): 877-881.

Kaplan, S. 1997. The words of risk analysis. Risk Analysis. 17(4): 407-417.

Kasemsuwan, S., Poolkhet, C., Patanasatienkul, T., Buameetoop, N., Watanakul, M., Chanachai, K., Wongsathapornchai, K., Metras, R., Marce, C., Prakarnkamanant, A., Otte, J. and Pfeiffer, D. 2009. Qualitative Risk Assessment of the Risk of Introduction and Transmission of H5N1 HPAI Virus for 1-km Buffer Zones Surrounding Compartmentalised Poultry Farms in Thailand. Pro-poor HPAI risk reduction. Mekong team working paper (7): 1-43.

Kung, N.Y., Morris, R.S., Perkins, N.R., Sims, L.D., Ellis, T.M., Bissett, L., Chow, M., Shortridge, K.F., Guan, Y. and Peiris, M.J. 2007. Risk for infection with highly pathogenic influenza A virus (H5N1) in chickens, Hong Kong, 2002. Emerg. Infect. Dis. 13(3): 412-418.

Kwon, Y.K., Thomas, C. and Swayne, D.E. 2010. Variability in pathobiology of South Korean H5N1 high-pathogenicity avian influenza virus infection for 5 species of migratory waterfowl. Vet. Pathol. 47(3): 495-506.

LBVD. 2007. Contingency plan for emergency control of highly pathogenic avian influenza (HPAI). Livestock Breeding and Veterinary Department, Ministry of Livestock and Fisheries, Myanmar. August 2007. 33-44.

Li, K.S., Guan, Y., Wang, J., Smith, G.J., Xu, K.M., Duan, L., Rahardjo, A.P., Puthavathana, P., Buranathai, C., Nguyen, T.D., Estoepangestie, A.T., Chaisingh, A., Auewarakul, P., Long, H.T., Hanh, N.T., Webby, R.J., Poon, L.L., Chen, H., Shortridge, K.F., Yuen, K.Y., Webster, R.G. and Peiris, J.S. 2004. Genesis of a highly pathogenic and potentially pandemic H5N1 influenza virus in eastern Asia. Nature. 430(6996): 209-213.

McLeod, A., Kobayashi, M., Gilman, J., Siagian, A. and Young, M. 2009. The use of poultry value chain mapping in developing HPAI control programmes. World's Poult. Sci. J. 65(2): 217-223.

Mon, C.C.S., Kyaw, T. and Win, T.T. 2008a. HPAI Surveillance in Duck, the targeted population. Proceedings, the 15th Congress of FAVA: FAVA - OIE Joint Symposium on Emerging Diseases.131-132.

Mon, C.C.S., Kyaw, T., Win, T.T., Yu, T.T. and Lwin, S. 2008b. Experience in HPAI Outbreak Containment. Proceedings, the 15th Congress of FAVA: FAVA - OIE Joint Symposium on Emerging Diseases.135-136.

Muarry, N., Mcdiarmid, S.C., Wooldridge, M., Gummow, B., Morley, R.S., Weber, S.E., Giovannini, A. and Wilson, D. 2004. Handbook on import risk analysis for animals and animal products. World Organisation for Animal Health, Paris, France.57.

Nishiguchi, A., Yamamoto, T., Tsutsui, T., Sugizaki, T., Mase, M., Tsukamoto, K., Ito, T. and Terakado, N. 2005. Control of an outbreak of highly pathogenic avian influenza, caused by the virus sub-type H5N1, in Japan in 2004. Rev. Sci. Tech. 24(3): 933-944.

Paul, M., Wongnarkpet, S., Gasqui, P., Poolkhet, C., Thongratsakul, S., Ducrot, C. and Roger, F. 2011. Risk factors for Highly Pathogenic Avian Influenza (HPAI) H5N1 infection in backyard chicken farms, Thailand. Acta. Trop. 26(42): 1-8.

Perkins, L.E.L. and Swayne, D.E. 2001. Pathobiology of A/Chicken/Hong Kong/220/97 (H5N1) avian influenza virus in seven Gallinaceous species. Vet. Pathology. 38(2): 149-164.

Photieng, T. and Jamjomroon, W. 2006. Avian influenza situation in wild birds. In Wildlife Yearbook. National Park, Wildlife, and Plant Conservation Department.(7): 249–254.

Promkuntod, N., Antarasena, C. and Prommuang, P. 2006. Isolation of avian influenza virus A subtype H5N1 from internal contents (albumen and allantoic fluid) of Japanese quail (Coturnix coturnix japonica) eggs and oviduct during a natural outbreak. Ann. N. Y. Acad. Sci. 1081: 171-173.

Rimmelzwaan, G.F., van Riel, D., Baars, M., Bestebroer, T.M., van Amerongen, G., Fouchier, R.A.M., Osterhaus, A.D.M.E. and Kuiken, T. 2006. Influenza A virus (H5N1) infection in cats causes systemic disease with potential novel routes of virus spread within and between hosts. Am. J. Pathol. 168(1): 176-183.

Sims, L.D. and Brown, I.H. 2008. Multicontinental Epidemic of H5N1 HPAI virus (1996-2007), in Avain Influenza. 1st Editon, D. E. Swayne (ed.). Ames, Iowa, USA, Blackwell Publishing. 251-286.

Sims, L.D., Ellis, T.M., Liu, K.K., Dyrting, K., Wong, H., Peiris, M., Guan, Y. and Shortridge, K.F. 2003. Avian influenza in Hong Kong 1997-2002. Avian Dis. 47(3 Suppl): 832-838.

Songserm, T., Amonsin, A., Jam-On, R., Sae-Heng, N., Meemak, N., Pariyothorn, N., Payungporn, S., Theamboonlers, A. and Poovorawan, Y. 2006a. Avian influenza H5N1 in naturally infected domestic cat. Emerg. Infect. Dis. 12(4): 681-683.

Songserm, T., Jam-On, R., Sae-Heng, N. and Meemak, N. 2006b. Survival and stability of HPAI H5N1 in different environments and susceptibility to disinfectants. Dev. Biol. (Basel) 124:254.

Songserm, T., Jam-on, R., Sae-Heng, N., Meemak, N., Hulse-Post, D.J., Sturm-Ramirez, K.M. and Webster, R.G. 2006c. Domestic ducks and H5N1 influenza epidemic, Thailand. Emerg. Infect. Dis. 12(4): 575-581.

Stegeman, A., Bouma, A., Elbers, A.R.W., de Jong, M.C.M., Nodelijk, G., de Klerk, F., Koch, G. and van Boven, M. 2004. Avian influenza A virus (H7N7) epidemic in the Netherlands in 2003: Course of the epidemic and effectiveness of control measures. J. Infect. Dis. 190(12): 2088-2095.

Swayne and Halvorson. 2003. Influenza in Diseases of Poultry, 11th edition. Barne HJ, Fadly AM, McDougald LR and Swayne DE (Editors). Iowa State Press, Blackwell Publishing Co.135-160.

Thomas, M.E., Bouma, A., Ekker, H.M., Fonken, A.J., Stegeman, J.A. and Nielen, M. 2005. Risk factors for the introduction of high pathogenicity Avian Influenza virus into poultry farms during the epidemic in the Netherlands in 2003. Prev. Vet. Med. 69(1-2): 1-11.

Tiensin, T., Ahmed, S.S., Rojanasthien, S., Songserm, T., Ratanakorn, P., Chaichoun, K., Kalpravidh, W., Wongkasemjit, S., Patchimasiri, T., Chanachai, K., Thanapongtham, W., Chotinan, S., Stegeman, A. and Nielen, M. 2009. Ecologic risk factor investigation of clusters of avian influenza A (H5N1) virus infection in Thailand. J. Infect. Dis. 199(12): 1735-1743.

Tiensin, T., Chaitaweesub, P., Songserm, T., Chaisingh, A., Hoonsuwan, W., Buranathai, C., Parakamawongsa, T., Premashthira, S., Amonsin, A., Gilbert, M., Nielen, M. and Stegeman, A. 2005. Highly pathogenic avian influenza H5N1, Thailand, 2004. Emerg. Infect. Dis. 11(11): 1664-1672.

Tumpey, T.M., Suarez, D.L., Perkins, L.E., Senne, D.A., Lee, J.G., Lee, Y.J., Mo, I.P., Sung, H.W. and Swayne, D.E. 2002. Characterization of a highly pathogenic H5N1 avian influenza A virus isolated from duck meat. J. Virol. 76(12): 6344-6355.

Webster, R.G. 2002. The importance of animal influenza for human disease. Vaccine. 20 (2 Suppl): S16-20.

Wee, S.H., Park, C.K., Nam, H.M., Kim, C.H., Yoon, H., Kim, S.J., Lee, E.S., Lee, B.Y., Kim, J.H., Lee, J.H. and Kim, C.S. 2006. Outbreaks of highly pathogenic avian influenza (H5N1) in the Republic of Korea in 2003/04. Vet. Rec. 158(10): 341-344.

WHO. 2010. Cumulative number of confirmed human cases of avian influenza A/(H5N1) reported to WHO as of 31 August 2010. World Health Organization. Available at:. http://www.who.int/csr/disease/avian_influenza/country/cases_table_2010_08_31/en/index.html.

Yamamoto, Y., Nakamura, K., Kitagawa, K., Ikenaga, N., Yamada, M., Mase, M. and Narita, M. 2007. Pathogenesis in call ducks inoculated intranasally with H5N1 highly pathogenic avian influenza virus and transmission by oral inoculation of infective feathers from an infected call duck. Avian Dis. 51(3): 744-749.

Yamamoto, Y., Nakamura, K., Okamatsu, M., Miyazaki, A., Yamada, M. and Mase, M. 2008. Detecting avian influenza virus (H5N1) in domestic duck feathers. Emerg. Infect. Dis. 14(10): 1671-1672.

APPENDICES

Appendix A

Duck Farmer Questionnaire Form

Section 1: Basic Information

1.1 Name of Owner .....

1.2 Address of Farm Owner .....

.....

1.3 Address of Farm .....

1.4 Location of Farm (GPS) Latitude.....Longitude.....

Section 2: Farm Management

2.1 Total number of duck in your flock .....

2.2 Age .....

2.3 Type Meat ☐ Layer ☐

2.4 Breeds of duck

Local ☐ Peking ☐ Cherry Berry ☐ Others ☐

Please specify.....

2.5 Sources of duck

Township..... Division.....

2.6 Which age of duck do you start for rearing at farm?

Day old duck ☐ Pullet ☐ First moulting ☐ Second moulting ☐

(over 1 year of age) (over 2 year of age)

2.7 Duration of flock keeping

Under 6 months ☐ 6-12 months ☐ 1-2 years ☐ Over 2 years ☐

2.8 How do you sell your duck/egg to market?

Direct to local market ☐ Through the dealer ☐

Where..... Which dealer.....

2.9 What type of containers do you use for duck egg and duck transportation?

Plastic basket ☐ Bamboo basket ☐ Wooden box ☐

2.10 Do you reuse this type of containers after cleaning?

Yes ☐ No ☐

Date of Interview.....

Name of Interviewer..... Time .....

Place of Interview: Township.....District.....Division.....

2.11 Do you give any feed supplement to your ducks?

Yes ☐ No ☐

If yes, what kind of feed supplement do you give? .....

Source of feed ....

2.12 Water supply for raising

Well ☐ Tube well ☐ Tap water ☐ Reservoir ☐

2.13 Where are you setting your ducks?

Wetland ☐ Canal ☐ Lake ☐ Paddy field ☐

2.14 How far is your farm from water reservoir?

.....Km

2.15 How far is your farm from the nearest town?

.....Km

2.16 How far is your farm from the main road that carried live poultry?

.....Km

2.17 Do you keep the other livestock together with ducks in your farm?

Yes ☐ No ☐

If yes, what sort of livestock do you keep? If no, go to question 2.18.

Chicken ☐ Quail ☐ Pet bird ☐ Pig ☐

Cattle/Buffalo ☐ Sheep/Goat ☐

2.18 Is there any chicken and quail commercial farm in radius 1km from your flock?

Yes ☐ No ☐ Not sure ☐

2.19 Do you see any wild birds in contact with your ducks?

Yes ☐ No ☐ Not sure ☐

If yes, which type of wild birds have you seen? If no, go to question 2.20.

.....

2.20 Do you move your flock to another place when the original place becomes dry or shortage of water supply?

Yes ☐ No ☐

If yes, how far from the original place? How to move? Please mention the location of new place.

.....

2.21 Did you see a mass mortality of ducks (1% mortality) in your duck farm during the last 6 month?

Yes ☐ No ☐ Not sure ☐

If yes, what clinical signs did you see? If no, go to Section 4.

.....

Section 3: Biosecurity

3.1 Duck production system

Free ranging ☐ Semi-intensive ☐ Intensive ☐

3.2 Which system do you use for selling of your ducks?

All in all out ☐ Partially ☐

3.3 How do you clean the farm?

Everyday ☐ One Time/week ☐ Other ☐.....

3.4 Do you make disinfection in the farm? Yes ☐ No ☐

If yes, how do you make? If no, go to question 3.5.

One time/week ☐ Two time/week ☐ Three time/week ☐

3.5 Who take responsibility for your ducks?

Worker ☐ Yourself ☐ Family member ☐

If yes at worker, how many workers are there in your farms? .....

Where are they staying? .....

3.6 Are there any visitors or relatives come to your farm?

Yes ☐ No ☐ Not sure ☐

If yes, how often they come?

Everyday ☐ Once a week ☐ Twice a week ☐

Section 4: Farmer Attitude

4.1 Do you know HPAI?

Yes ☐ No ☐

If yes, keep in ask the following questions:

4.2 Do you know the clinical sign of HPAI?

Yes ☐ No ☐

If yes, what clinical signs do you know? .....

.....

4.3 What do you think the introduction of HPAI into your farm?

Wild birds ☐ Visitors ☐ Contaminated materials ☐ Not sure ☐

4.4 What do you think the transmission of HPAI from farm to farm?

Egg trays ☐ Feed bags ☐ Visitors ☐

4.5 If you have any health problem in your farm, to whom you consult?

Local authority ☐ Township Vet: ☐ Private Vet: ☐ Animal Health ☐
Duck expert ☐ worker

Section 5: Additional check list for farm environment:

5.1 No. of housing……

5.2 How far is between farmer house and duck house? ……

5.3 Net Using Yes ☐ No ☐

5.4 Rodent Yes ☐ No ☐

Note:

In 2004, FAO identified poultry production sectors:

Intensive: Ducks are kept in total confinement. All facilities are provided i.e. water and feed in a sheltered area or pen.

Semi Intensive: Ducks are free to go from pen to an outdoor extension or 'run' during the day where they feed freely on insects and worms. This helps to provide added nutrition and assists in balancing their diet.

Free-ranging: Duck are moved around the property, often over long distance and across the township. All facilities are not provided.

Location of the Duck Farm

Interviewer: Please draw location of the duck farm

Appendix B

Poultry Supply Chain Questionnaire Form

Section 1: General information

1. Name of participant……

2. Address ……

……..

3. What is your occupation?

1. Meat seller	☐	4. Egg dealer	☐	7. Day old chick dealer	☐	10. Feed dealer	☐
2. Live poultry dealer	☐	5. Hatchery owner	☐	8. Day old quail dealer	☐	11. Manure collector	☐
3. Egg seller	☐	6. Day old duck dealer	☐	9. Feather dealer	☐		

If yes in No. 1 to 4, go to left column.

If yes in No. 5 to 11, go to right column.

Section 2: Supply chain information

4. Identify types

Village chicken	☐	Duck	☐
Layer	☐	Quail	☐
Broiler	☐		

5. Source (where do you collect)

Where……

From whom……

How frequent……

6. Place of distribution (where do you sell)

Outside township……

Inside township……

Local market……

Home ……

7. Daily selling volume……

……

……

4. Identify types

Day old chick	☐	Feed	☐
Day old duck	☐	Feather	☐
Day old quail	☐	Manure	☐

5. Source (where do you collect)

Where……

From whom……

How frequent……

6. Place of distribution (where do you sell)

Outside township……

Inside township……

Local market……

Home ……

7. Daily selling volume……

……

……

Date of interview……

Name of interviewer …… Time ……

Place of interview: Township ……District……Division……

8. Buying price of live birds /egg:

Village chicken……kyats/kg

Layer……..kyats/kg

Broiler……kyats/kg

Duck……..kyats/kg

Quail……..kyats/head

Chicken egg……kyats/egg

Duck egg……..kyats/egg

Quail egg……..kyats/egg

9. Selling price of live bird/egg

Village chicken……kyats/kg

Layer……..kyats/kg

Broiler……kyats/kg

Duck……..kyats/kg

Quail……..kyats/head

Chicken egg……kyats/egg

Duck egg……..kyats/egg

Quail egg……..kyats/egg

10. What kind of containers do you use for transport?

……..

11. Do you reuse these containers?

Yes ☐ No ☐

If yes, how do you clean the container?

……..

12. How do you transport the poultry and poultry products?

By…….

13. Peak production time:

……..

8. Buying price of:

Fertile duck egg (hatchery) ……kyats/egg

Day old chick……....kyats/head

Day old duck……....kyats/head

Day old quail……..kyats/head

Feed……kyats/bag

Feather……kyats/bag

Manure ……kyats/bag

9. Selling price of:

Day old chick……kyats/head

Day old duck……..kyats/head

Day old quail…… kyats/head

Feed……kyats/bag

Feather……kyats/bag

Manure ……kyats/bag

10. What kind of containers do you use for transport?

……..

11. Do you reuse these containers?

Yes ☐ No ☐

If yes, how do you clean the container?

……..

12. How do you transport the poultry and poultry products?

By…….

13. Peak production time:

……..

BIOGRAPHY

Mr. Htun Htun Win, a Myanmar graduate student was born on June 6, 1981 in Central Myanmar. He obtained Bachelor of Veterinary Science degree from the University of Veterinary Science, Yezin, Myanmar, in 2006. He is working as an Epidemiologist at the Epidemiology Unit, Veterinary Diagnostic Laboratory, Research and Disease Control Division, Livestock Breeding and Veterinary Department, Yangon, Myanmar. In 2009, he was enrolled in a Master degree program to study field epidemiology at the Department of Veterinary Public Health, Chulalongkorn University. This study program is supported by Food and Agriculture Organization of the United Nations and the World Bank.