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Animal biosecurity in the Mekong: future directions for research and development

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Animal biosecurity in the Mekong: future directions for research and development

Proceedings of an international workshop held in Siem Reap, Cambodia, 10–13 August 2010

Editors: L.B. Adams, G.D. Gray and G. Murray

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Cover: Children observing a serological survey and learning how the survey can improve their health and the health of the animals in their village (Takeo, Cambodia). (Photo: Domingo Caro III)

Foreword

Livestock disease constrains livelihood development in the Mekong countries in multiple ways: through loss of animals and their productivity, restriction of trade within and between countries and, more recently, the diseases that can be transmitted from livestock to humans. Many of the methods used to contain these diseases and prevent their transmission are brought together under the general heading of biosecurity, which is the focus for many national and international organisations. The lead international agency with responsibility for trans-boundary diseases that affect trade is the World Organisation for Animal Health (OIE). The Australian Biosecurity Cooperative Research Centre for Emerging Infectious Disease (AB-CRC) has supported research in Australia and Asia that spans animal and human biosecurity. The Australian Centre for International Agricultural Research (ACIAR) has been a long-term supporter of research partnerships that address both endemic and epidemic disease, including foot-and-mouth disease, classical swine fever and avian influenza.

The OIE, the AB-CRC and ACIAR have supported research and development for biosecurity in the Mekong countries through collaborations among institutions in Burma (Myanmar), Cambodia, Lao PDR, Thailand and Vietnam, with international agencies such as the Food and Agriculture Organization of the United Nations and the World Health Organization and, in many cases, with Australian partners. It is a shared goal of all these organisations to improve animal biosecurity in the region as a significant pathway to improving food security and reducing poverty.

These collaborations have sought to build national and regional capacity to prevent, control and, where appropriate, eradicate livestock diseases through formal and informal training. Research has been supported on endemic and epizootic diseases of national and international significance, as has the strengthening of animal health services. There has been a strong commitment to the development of skills in risk analysis, epidemiology, communication, pathogen detection, disease ecology and surveillance, legislation and governance, contingency planning and risk-based strategies for managing livestock movements.

To strengthen and refocus these initiatives it was considered timely to convene a workshop for the organisations and key stakeholders to examine achievements, assess future gaps and needs in research and development of direct relevance to ACIAR and OIE priorities in the Mekong, and identify opportunities to further develop research linkages between the region and Australia. The Cambodian Ministry of Agriculture Forestry and Fisheries, through the

Department of Animal Health and Production, kindly hosted the workshop in Siem Reap in August 2010. ACIAR is pleased to support the publication and distribution of the proceedings and to continue working closely with the participating individuals and their organisations.

Nick Austin
Chief Executive Officer
ACIAR

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Introduction

Livestock markets are opportunities for disease transmission between animals and for promoting disease control programs. (Photo: Sieng Socheat)

Workshop summary

Lisa Adams, Doug Gray and Gardner Murray

Background

The Australian Centre for International Agricultural Research (ACIAR), the World Organisation for Animal Health (OIE), the Australian Biosecurity Cooperative Research Centre for Emerging Infectious Disease (AB-CRC) and the Cambodian Ministry of Agriculture, Forestry and Fisheries (MAFF) hosted the workshop 'Animal biosecurity in the Mekong—future directions for research and development' in Siem Reap in August 2010 to:

- examine what their research and development (R&D) collaborations have achieved in animal biosecurity over recent years
- assess future gaps and needs in R&D of direct relevance to ACIAR and OIE programs and priorities, with a focus on animal biosecurity in the Mekong
- identify opportunities to further develop and strengthen research linkages between the Mekong countries, OIE and Australia.

The workshop was presided over by H.E. Om Kimsir, Secretary of State, MAFF, Royal Government of Cambodia. In their welcoming remarks, H.E. Mao Vuthy, Deputy Governor of Siem Reap province, H.E Kao Phal, Director of Animal Health and Production, MAFF, and H.E. Om Kimsir all noted the positive changes to people's livelihoods in rural areas, and that agriculture, livestock production, food security and food safety have contributed positively to these changes. Major challenges to the livestock sector include responding to the global economic crisis, global climate change and natural disasters, and emerging and other animal diseases. The livestock sector faces many challenges; there is a need to accelerate growth of the sector by improving feed, breeding and research, and by introducing modern technology and new knowledge about biosecurity management systems to control infectious diseases. The need to work with international development agencies and R&D partners towards development goals was highlighted, as was the need to plan research that contributes to reducing poverty and developing the agricultural sector and rural areas in the Mekong.

Cambodian perspective on biosecurity

Dr Sen Sovann, Deputy Secretary General, MAFF, emphasised that the role of agriculture is multifunctional and includes providing employment, increasing productivity and commercialisation, and ensuring food security and food safety. Cambodia's policy directions and programs for agriculture and water development, and the importance of biosecurity to policy and program priorities were explained.

Dr Sovann noted that in Cambodia, livestock production is resource limited, focused on the smallholder livestock producer, and important for families as a source of protein and for economic security. The challenge is for farmers to move to market-supply agriculture. Farmers need self-supporting measures to increase animal health and production, and to be able to supply animal products to markets. Important questions are:

- How can we assist smallholders in market access and to produce safe product?
- How can this be done while addressing the challenges of climate change, managing water resources and trans-boundary animal diseases?
- What are the optimal biosecurity measures and good husbandry practices that should be used by farmers?
- What areas do we invest in for biosecurity for small to medium enterprises?
- How do we develop and apply national and regional standards for good agriculture and husbandry practices, including for animal production, food safety, sanitation and biosecurity?

- What public awareness measures need to be put in place to meet trade-related biosecurity and food safety requirements in the context of agricultural development?
- How do we package what we know so smallholder farmers can use it?

Smallholder farmers need to have optimal, affordable and practical biosecurity measures that they can understand and implement. The measures need to deliver mutual benefits to both the farmer and the consumer.

In response to questions from workshop participants, Dr Sovann explained that the public sector needs to serve the smallholder, who represents the majority of agriculture in Cambodia. The smallholder can often produce more with limited resources, but the major challenge is that the product cannot be brought to market. Biosecurity for market access is supported by a biosecurity science and infrastructure, but the smallholder 'cannot buy it'. How can we develop affordable, practical biosecurity measures that smallholders can learn and use? How does the public sector adapt international standards for sanitation and biosecurity to make them applicable to the farmer? This is a challenging task.

International perspectives on biosecurity

Dr Gardner Murray noted that a high proportion of existing and emerging infectious diseases (EIDs)[1] of humans are of animal origin. Together with a number of significant trans-boundary animal diseases, such as foot-and-mouth disease and porcine reproductive and respiratory syndrome, these have had serious adverse socioeconomic impacts.

Factors contributing to the emergence, spread and amplification of EIDs include increased population growth; growth and demand for animal protein; trade; intensive animal production; urbanisation; environmental degradation; the convergence of animals, humans and wildlife; political and social disruption; and climate change and variability.

Dr Murray described the supply and demand of livestock and livestock products, and potential looming problems associated with a global population forecast to increase 50% by 2050, largely in South-East Asia, and a 2–3% increase in demand for animal protein each year for the next 10 years. He emphasised the importance of EIDs that have had, and will continue to have, serious socioeconomic impacts.

Given these factors, it can be safely assumed that the risks of EIDs are increasing, but the nature of such diseases is very difficult if not impossible to predict. To minimise risk, a long-term integrated and adequately resourced biosecurity system is needed, a key component of which is R&D.

The need for focused R&D targeted to short-, medium- and long-term approaches was highlighted. Although many of the technical challenges can be managed using existing skills and knowledge, there is a clear and ongoing need for developing and introducing new diagnostic techniques, vaccines and pharmaceuticals, as well as improving epidemiological techniques, risk analysis and informatics systems. Technical, short-term R&D should address areas of immediate concern and include assessments of their results, practical application and relevance.

Dr Murray suggested that research into the socioeconomic aspects of biosecurity is important, particularly at the village and community level. The role of gender is important, as is determining how to transfer simple technologies, effect behavioural change, communicate effectively and undertake on-farm micro-economic assessments.

R&D needs a planning and interdisciplinary approach, and recognition that it is not an end in itself; rather, it is there to support overall animal and public health programs and national wellbeing.

Dr Murray discussed the outcomes of the Inter Ministerial Conference on Avian and Pandemic Influenza (IMCAPI, Hanoi, 2010) and the policy/strategic framework adopted as a result of the lessons learned from the highly pathogenic avian influenza H5N1 experience. He summarised these as the need to:

- move from an emergency response mode to sustainable systems
- increase in-country animal and public health capacities
- pay attention to, and engage at the community and district levels
- engage the private sector through partnership arrangements
- avoid neglecting emergency management and contingency planning activities

[1] EIDs are diseases that have recently increased in severity, incidence or geographic range, moved into new populations, or are caused by newly evolving pathogens.

- continue to cooperate at regional and global levels on prevention, management and information systems because of the nature of and rapidity of spread of a number of highly infectious diseases
- progressively adopt or improve 'One Health' approaches.

Workshop process

Thirty-eight participants from six countries contributed expertise in animal health and agricultural development, specifically in veterinary science, animal production, economics, trade, communication, extension, biosecurity, and policy and program management. They participated in four half-day sessions that considered the themes:

- disease control, risk and biosecurity
- patterns of livestock production, movement and trade
- biosecurity systems and capacity
- disease control programs.

Each theme was introduced by a lead paper and two or three short papers to set the scene for discussions using a structured, facilitated format to explore a range of ideas, and to consolidate these ideas into narratives that tell the story of:

- How does the world look now?
- What issues do we confront?
- What trends and drivers can we identify?
- What scenario can we reasonably look forward to in 5–10 years?
- What steps need to be taken to progress towards a positive scenario?
- Who needs to do what?
- What are the unknowns?
- What questions need to be answered for good decisions about the future?
- Which of these questions can be answered through research partnerships between Australia and the region?

Discussion summaries

Emerging infectious diseases have had, and will continue to have, serious economic and social impacts. Global responses to emerging and trans-boundary diseases are essential for protecting animal and public health, improving food security and reducing poverty. However, these responses have mostly been based on emergency responses with insufficient emphasis on longer term and more sustainable prevention and control programs. Many contributors to the workshop underscored the need for more holistic and integrated approaches to biosecurity R&D with refocused and increased investment to:

- engage stakeholders in appropriate ways to ensure R&D programs respond to genuine needs
- identify and support clear development pathways from research to impact
- develop programs that benefit all stakeholders, especially smallholder farmers and communities in the Mekong region
- develop a better understanding of market chains for livestock and livestock products as a framework for improved biosecurity.

Specific recommendations were made in the areas of capacity building, information support, responding to genuine demand, engagement with stakeholders and the market chain.

Capacity building

The importance of capacity building was discussed in every session along with new approaches and methods that may make capacity building more effective. This is a significant issue for all agencies that invest in formal and informal training. For example, the AB-CRC has supported a comprehensive PhD training program and ACIAR funds degree training programs and builds on-the-job training into the design of all projects. These large investments were agreed to be worthwhile, especially as the training context has recently shifted to focus on regional problems rather than technical training in non-Asian countries. There remains a need to experiment with different modalities, to find the best practice appropriate for each country and disease problem. It was emphasised that training alone is not enough to build capacity and that a network of appropriate mentoring, collaboration and exchange needs to be integrated with national or regional training programs.

Information support

Information support and knowledge sharing was another important theme of the workshop and focused on two main areas:

- ensuring there is information exchange to support the development of new R&D projects
- maximising the probability that research outputs will be available for development initiatives by national and international agencies. There is a great deal of material that is not published, and

is not suitable for scientific publications; much of this material is only available through informal networks. ACIAR and OIE will continue to play a role in improving information sharing through web-based publishing of technical reports and proceedings. Individuals can (and many do) share information and add value to that information by guiding people to information sources and highlighting aspects that are relevant.

Better data of all types are needed across the board, including data on laboratory diagnosis, disease reporting, animal movement and outbreak reporting. Generating data, its storage, dissemination and interpretation are continuing challenges.

Responding to demand

Planning for R&D is shaped by competing demands to, for example, meet targets for development goals, reduce poverty among the rural and urban poor, increase local food security, stimulate economic growth and, especially in the case of biosecurity, meet international standards. Giving voice to and prioritising these demands requires participation of all stakeholders in all stages of the R&D cycle from initial conception, through implementation and to review. It was the general feeling of the meeting that it is often unclear which of these demands are being addressed. A more balanced approach to investment in disease prevention and control is required to ensure the needs of the poor are met in the region and in individual countries.

Some technologies and approaches, based on 'western' models, may not respond to genuine development demands. It is essential to consider the principles and processes that led to successful development of these models in one country, for example in Australia, and consider carefully how this might be applied in the diverse political, social and economic circumstances of the Mekong region.

Workshop participants supported Dr Murray's view that although many of the technical challenges can be managed using existing skills and knowledge, there is a clear and ongoing need for developing and introducing new diagnostic techniques, vaccines and pharmaceuticals, and improving epidemiological techniques, risk analysis and informatics systems.

Ongoing socioeconomic studies are required for scoping researchable issues and the potential for R&D to deliver sustainable benefits to communities.

Engagement with stakeholders

During the workshop there were consistent requests for sociological, economic or communication skills for projects that have reached a barrier to adoption or understanding. A possible explanation for these barriers is that such skills and disciplines have not been integrated into project design at inception if it is foreseen that they are likely to be needed. This is true for all disciplines and all stakeholders as R&D moves through the project cycle from conception through implementation to development and scaling up. Different types of engagement are needed: the simple exchange of information through dialogue to full partnership where resources, risks and decisions are shared. The appropriate level of engagement needs to be decided for all stakeholders and this is likely to change as projects progress. The use of participatory approaches at all levels was emphasised in many presentations.

Market chain

The challenge for farmers in many countries in the Mekong is to move from subsistence to market-oriented agriculture. Farmers need self-supporting measures and incentives to increase animal health and production and to be able to supply animal products to markets. Future R&D needs to be guided by the questions raised by Dr Sen Sovann in his opening presentation (see above), and must recognise that disease control is one of many constraints to accessing markets.

Accordingly, R&D projects need to consider and support the whole market chain, including input markets for animal health and other products, and output markets for live animals and livestock products. ACIAR has supported a number of different projects in this area and it is becoming a standard framework for the development of 'research for development' projects. Understanding these market chains requires a diverse range of expertise and any successes achieved so far have involved understanding of market chains by those participating in them, not just the researchers and others who have studied them.

Development pathway

How do we link the research to a pathway toward significant development, and including changes in the practices and behaviours of next users and end users? One example presented at the workshop from northern Lao PDR was of a large development project in which several research projects have become attached or embedded. In itself this promotes sustainability as the development project generates research problems that are immediately relevant, and the research projects can evaluate new technologies and approaches in a 'real world' development setting. Other examples were to involve non-government organisations and identify advocacy roles for scientists in the project. There is a need to consider what policymakers need and use their language: that of the 'Economist' or 'Asia Weekly' and in addition to 'Preventive Veterinary Medicine' or 'Transboundary and Emerging Diseases'. Policymakers do not need the detailed research results; they need to know what it means for their decision-making. Projects need a communication strategy, and an exit strategy to ensure their legacy.

Conclusions and agreement

Workshop participants formally supported the following summary findings and conclusions from the workshop:

- A major challenge for governments and communities in the Mekong region is to increase animal productivity and trade by facilitating the development of the whole market chain and supporting food safety.
- Improving the management of biosecurity risks and meeting international biosecurity standards is increasingly important for improving animal productivity, expanding and diversifying market opportunities in the region, and protecting public health.
- There is demand now (and there will be increasing demand) for knowledge, tools and systems, and for education and training, to better manage biosecurity risks across the market chain and to achieve government development objectives to reduce poverty and increase food security.
- ACIAR and OIE, through their collective investments in regional coordination, research and development, have an important role for supporting governments and communities to meet this increasing demand.
- ACIAR and OIE should collaborate to build each other's capacity and synergy for improving regional coordination and biosecurity for the Mekong region and to explore broader strategic R&D partnerships with others in the region.
- The following approaches for biosecurity R&D are required
  - Designing projects that respond to genuine demands and economic, social and cultural requirements, and with the countries and communities in the region taking the lead.
  - Strengthening stakeholder engagement whereby stakeholders are partners in the research, have a strong investment in the outcomes of the research and, importantly, include the private sector.
  - Integrating biosecurity research with animal health, production and the market chain.
  - Ensuring projects have a development pathway and a strong element of capacity building.
  - Improving cross-border and regional cooperation and networks.
  - Setting standards for project development, implementation, monitoring and evaluation, and continuous improvement consistent with best practice.
- Three priority areas for future biosecurity R&D are identified to better support ACIAR and OIE programs in the Mekong
  - Improving community-based biosecurity.
  - Integrating biosecurity with improving animal health, productivity and market opportunities.
  - Implementing international biosecurity standards complemented by measures appropriate to the social, cultural and economic needs of the community.

Disease control, risk and biosecurity

Mixing cattle from different sources for transport increases the risk of disease transmission. (Photo: Ben Madin)

Biosecurity 2020—looking forward 10 years

Peter Black

The range of drivers that will affect the biosecurity landscape of the Greater Mekong Subregion (GMS) in the next 10 years are interconnected. An extensive analysis of all the so-called STEEP categories (i.e. social, technical, economic, environmental and political) is not possible in this short paper. However, a brief examination of some of the major drivers—which can be predicted with some confidence over a 10-year time frame—does paint a picture with enough detail to draw some reasonably robust conclusions.

It is important to recognise that biosecurity is now being viewed as one component of a more broadly based security interest. The term 'non-traditional security' (NTS) refers to issues that challenge the survival and wellbeing of peoples and states that emerge from non-military sources. NTS issues include climate change, resource scarcity, infectious diseases, natural disasters, irregular migration and famine (Caballero-Anthony 2008). Biosecurity-related issues are a subset of the infectious disease category. The particular characteristics of these NTS issues are that they can arise without much warning and often spread very quickly due to the increasing interconnectedness of societies.

Biosecurity can also be viewed as a key component of animal health systems and there is an increasing interest in improving such systems as a 'global public good'—not only to reduce poverty and provide food security, but also as a key component to protect human health by improving the systems that will detect and respond to emerging infectious diseases of humans. This work is clearly a component of the 'One Health' approach that is increasingly being adopted globally (FAO et al. 2008).

Major drivers

Human population

The GMS comprises Cambodia, Burma (Myanmar), Lao PDR, Thailand, Vietnam, and Yunnan province in the People's Republic of China (PR China) (ADB 2010a). However, for the purposes of this paper—that clearly recognises the critical importance of the growing level of interconnectedness—the whole of mainland China will be considered. The forecast human population for the years 2010 and 2020 of each country is listed in Table 1.

Economic growth

The economic growth rates of these countries, although variable, do include four countries with figures of greater than 5% (see Table 2) and PR China is now recognised as the second largest economy with an annual gross domestic product approaching US$4.9 trillion.

Such rapid growth rates are manifest not just in economic performance figures, but also in changing dietary preferences. South-East Asia has the most rapid increase in per capita intake of energy derived from livestock products of any region (FAO 2009). The increasing population, coupled with this change in dietary preferences, translates into very rapid increases in demand for meat in the region (FAO 2009). Based on current projections in the region, in most countries demand will exceed supply, in some cases by a considerable margin (Business Monitors International 2010). The increased demand for meat is relevant to biosecurity practices in the region. For example, increased demand will have direct effects on the movement of animals and livestock products within and between GMS countries and on subsequent disease control efforts.

Urbanisation

Urbanisation (in combination with underlying population growth) is a driver for increased demand for meat and other animal products (FAO 2009). The comparative rates of urbanisation for the GMS countries are shown in Table 3.

The changes are due primarily to people moving from rural areas to towns and cities in each country.

By 2020, in all countries apart from PR China, more than 50% of the population will still be living in rural environments. Many of these rural people will be keeping livestock, but what proportion will still be subsistence farmers is debatable and difficult to forecast with confidence. In any case, the livelihoods of these people need to be protected and their quality of life improved as part of the development pathway for each of these GMS countries (FAO 2009).

Infrastructure

Although the rates of economic growth in the region—most particularly PR China—are expected to decline slightly, the levels of investment in infrastructure for road and rail transport will still be massive. Although not the only significant source of finance in the region, the Asia Development Bank does maintain a list of the infrastructure projects in the region that it

Table 1. The forecast human population for the years 2010 and 2020 for each Greater Mekong Subregion country

Country	Human population by year (millions)	
	2010	2020
Burma	50.5	55.5
Cambodia	15.0	17.7
Lao PDR	6.4	7.6
People's Republic of China	1,354.1	1,431.2
Thailand	68.1	71.4
Vietnam	89.0	98.0
Total	**1,583.1**	**1,681.4**

Source: United Nations (2010)

Table 2. Gross domestic product (GDP) growth rates for each Greater Mekong Subregion country in 2009

Country	GDP growth on an annual basis adjusted for inflation and expressed as a %
Burma	5.1
Cambodia	–2.0
Lao PDR	7.6
People's Republic of China	10.3
Thailand	–2.3
Vietnam	5.3

Source: CIA (2010)

Table 3. Human population classified as living in urban environments in Greater Mekong Subregion countries

Country	2010		2020		% increase
	Number in millions	%	Number in millions	%	
Burma	16.99	34	22.57	41	7
Cambodia	3.03	20	4.21	24	4
Lao PDR	2.13	33	3.38	44	11
PR China	635.84	47	786.76	55	8
Thailand	23.14	34	27.8	39	5
Vietnam	27.05	30	36.27	37	7

Source: United Nations (2010)

supports (ADB 2010b) and this list gives an indication of the level of infrastructure development.

Other examples of planned infrastructure projects in the region are listed below:

- In China alone, the stimulus package designed in response to the global financial crisis focuses very heavily on investments in rail and road. The Chinese expect to expand the current 86,000 km rail network to 120,000 km by 2020, with parts built to cater for trains that can travel at 350 km per hour. The total mileage of China's road highway network will reach 3 million km by 2020 and form a high-speed goods communication network. This expansion is apparently driven by the dual motives of catering for growing urban populations and integrating the underdeveloped central and western provinces of the country (including Yunnan province) so that developing an appropriate transport system will become the backbone of the Chinese economy.
- In Vietnam, plans include the development of a north–south road 3,262 km long, and improvements in rail infrastructure to improve the speed of freight and passenger lines. Road links with PR China will be improved with two expressways from Vietnam to the southern province of Guangxi.
- The Singapore to Kunming railway is expected to be completed between 2015 and 2020.
- An 11.6 km bridge is planned to connect the northern Thai province of Chiang Rai with the Laos province of Bokeo, and further to Yunnan province in southern China.

Within the GMS, there is an explicit desire to facilitate trade across borders with a cross-border transport agreement that seeks to integrate the trade practices of the GMS countries. The aims of this agreement include having a single-stop customs inspection point, establishing minimum standards for the design and reliability of infrastructure, providing cross-border visas for people engaged in transporting goods, and instituting transit traffic regimes (ADB 2010c).

Changing animal production and marketing—environmental and economic influences

Over the next 10 years and beyond, environmental issues such as climate change, water scarcity and changes in land-use practices will encourage a move towards new production systems. Some of these production systems will be more intensive and or more commercial in nature. For example, as the economies in the region grow, some of the people living in rural environments will not necessarily intensify their production system but may become more commercial or larger scale cattle producers (such as in the 'ranching sector'). Irrespective of what is the driver for more intensive or more commercial operations, biosecurity concerns in such operations become more important. Indeed, the interconnected nature of environmental issues and production and disease issues has been well described in the literature (Otte et al. 2007; FAO 2009).

The actual location of animal production will also be directly affected by the competing demands for resources such as water and land. In addition to change in production, as economies grow, the type of product required is also likely to change (e.g. people entering the middle class with higher disposable incomes depending less on live animals and more on supermarkets). This could see resurgence in the operation of the larger and more sophisticated slaughterhouses, with higher throughput rates and more attention on food safety. The growth of white-good consumption, including refrigeration, in PR China is already changing consumer buying patterns; by 2020 this trend may be evident in a number of countries such as Vietnam.

Conclusion

This brief paper has discussed a number of drivers that will influence the biosecurity landscape of the GMS in the next 10 years. These drivers do not act in isolation but as a complex, interconnected system that will continue to evolve. The results of these interactions will manifest in different ways at a range of scales from the village up to the inter-country scale and will include some cross-scale interactions.

In general, this interconnectedness will increase the rate and extent of movement of animals and animal products in the region, with an accompanying increase in the likelihood of spreading disease. The trend towards intensification and commercialisation of animal production systems will also increase the need for improved biosecurity to avoid disease entry, establishment and spread. However, the implementation of improved biosecurity practices will need to be embedded within the animal production systems—not treated as an 'add on'. This means that the stakeholder attitudes to disease and animal production along the whole market chain must be fully appreciated before designing biosecurity programs and strategies. This issue is discussed in a number of papers in this volume.

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Establishing preborder biosecurity—avian influenza control and poultry trade in East Nusa Tenggara province, eastern Indonesia

Maria Geong and Jenny-Ann Toribio

There are many regulations in place for the movement of poultry and poultry products from other provinces of Indonesia into East Nusa Tenggara (ENT) province; these are principally to protect ENT against the introduction of highly pathogenic avian influenza H5N1 (HPAI H5N1).

In ENT, poultry meat consumption is second only to pork, and ducks have an important sociocultural role in rituals and ceremonies (Christie 2007). Poultry are predominately raised in villages (sector 4) and the few small commercial farms (sector 3) that supply larger provincial towns are the only farms that require supply and feed from companies outside ENT. Known sources of live poultry and poultry products for ENT are Java, Bali and South Sulawesi—with Java and Bali providing day-old chicks (DOC) until 2004.

The first case of Asian-lineage HPAI H5N1 among poultry in Indonesia occurred in central Java during August 2003. In Bali and South Sulawesi, other important sources of poultry for ENT, the first poultry cases occurred in late 2003. During 2003–04, the outbreaks in Java, Bali and South Sulawesi were widespread, including farms belonging to all four sectors of the poultry industry in Java, all nine districts of Bali on sector 3 and sector 4 farms, and in chickens, ducks, quail and pigeons (Santhia and Putra 2004). Since then, the disease is officially recognised to have infected poultry in 31 of the 33 provinces in Indonesia; islands known to have ongoing endemic infection include Java, Sumatra, Sulawesi and Bali. To 3 August 2010, 168 human cases have been reported in Indonesia resulting in 139 deaths (case fatality rate of 83%) with the majority of these cases on the island of Java. Direct or indirect contact with poultry is a common feature among human cases in South-East Asia (Dinh et al. 2006; Sedyaningsih et al. 2007).

HPAI was recognised as a serious threat to the health of poultry in ENT. In response to this threat, since 2004 the provincial government has made a major effort to ensure safe and efficient poultry trade and keep ENT free from HPAI. First, a total ban on poultry movement into ENT was implemented by governor decree from February to April 2004. A qualitative risk assessment then ranked the pathways of HPAI entry into ENT as:

1. live chickens and ducks
2. poultry products (eggs, frozen carcasses, processed meat)
3. contaminated fomites (poultry equipment and transport vehicles)
4. wild birds.

Subsequently, the complete ban was replaced by restricted movement of live poultry and poultry products into the province (Table 1).

The policy considered the risk for introduction posed by province, farm sector and type of product (live bird, meat, egg, other) and as a result instigated a system to inspect and license a small number of low-risk farms in Java as the only sources of DOC, fresh eggs and frozen meat for ENT. Poultry and poultry products from anywhere else were not permitted to enter the province.

The licensed source farms were inspected periodically by a team of veterinary and industry experts from ENT, to ensure that they continued to meet the specified requirements such as high biosecurity, HPAI vaccination, evidence of protective antibody titre, certificate of animal health and production level (egg production >100,000 eggs/day; DOC production >250,000 DOC/day). The approved farms were commercial poultry farms located in East Java with three permitted to supply commercial DOC and

Table 1. Live poultry and poultry products from other provinces of Indonesia permitted/not permitted into East Nusa Tenggara province

Commodity	Permitted	Not permitted
Live poultry	Commercial DOC from licensed farms <2 weeks old	Commercial DOC >2 weeks old All other live poultry
Eggs	Fresh commercial egg—chicken Processed/salty egg—chicken and duck	All other fresh poultry egg
Frozen carcass and meat	Commercial broiler	All other poultry carcass
Other product	None	Manure Poultry feathers Litter

DOC = day-old chicks

five to supply fresh eggs. In addition, there were three commercial slaughterhouses approved to supply frozen chicken carcasses and meat. All these licensed facilities were required to follow improved quarantine procedures at the one selected export point in Surabaya East Java (quarantine inspection of product and documents; disinfection; application of quarantine labels to inspected commodities) and the six import points in ENT (quarantine inspection of label, product and documents; disinfection). Reports of these quarantine inspections were provided to the provincial office of Quarantine and Livestock Services ENT.

This policy was formulated with stakeholder participation. The ENT Poultry Farmers Association was engaged in the decision-making process and represented on the provincial Poultry Health & Production Committee established to inspect and assess source farms in East Java. The local media were provided with updates on HPAI to increase public awareness of the disease. Surveillance activities were also strengthened to ensure early detection and response to any incursions.

To date, this preborder approach to biosecurity has largely protected ENT from HPAI. The two reports of HPAI H5N1, the first during October 2004 in Kupang, were both effectively controlled by focal depopulation. Structured surveys held from 2005 as part of active surveillance for HPAI by regional government authorities and university researchers have failed to detect antibody or virus in samples from poultry in ENT.

Success in preventing the introduction and establishment of HPAI in ENT is the result of biosecurity policy based on scientific principles and its implementation in a collaborative and strong community. Features of this process that are considered to be central to its success include:

- using a risk-based approach—qualitative risk assessment identified the highest risk pathways of HPAI entry and formulation of biosecurity policy mitigated against these identified risks
- collaboration between government and industry—ENT Quarantine and Livestock Services agreed on this policy and sustained collaboration after it was implemented. The poultry industry was included in discussions and representatives are members of the provincial Poultry Health & Production Committee
- political will to protect provincial interest—policy was implemented by governor decree and withstood resistance from poultry companies in Java and Bali
- education of industry and the community—education was facilitated by involving the local media, conducting focus group discussions with stakeholder groups and including the Poultry Farmers Association in policy development and implementation
- limited incentive for illegal movement of poultry into ENT—the market demand for healthy birds in ENT is met by local production under the current policy and there are few social ties with neighbouring provinces that might foster informal bird movement
- severity of HPAI—it was widely recognised that the introduction of HPAI would have severe consequences for the local poultry industry and, as a zoonotic disease, also for human health
- free status of ENT—HPAI is an easier disease to keep out than to contain and eradicate. The limited incursions in ENT due to efficient management did not create complacency about the disease or

angst over culling without compensation among producers.

This example of preborder biosecurity shows that disease entry can be prevented through strategic and collaborative action at the provincial level in the decentralised governmental system of Indonesia.

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Making use of expert opinion for biosecurity decisions

Greg Hood, Mark Burgman and Simon Barry

To keep countries or regions free from disease, or limit the spread of endemic disease, biosecurity decisions should be made using the best available information. For many decisions, however, rigorous statistical information will not be available, or it will need to be supplemented using information from domain experts—such as people who work in the area where a pest or disease occurs. Obtaining opinions is cheap and easy compared with designing experiments, collecting data and statistically analysing the results, but the use of opinions for risk assessment has some problems, which we discuss below.

To improve the contributions that experts make to risk assessments—and to improve biosecurity decisions more generally—the Australian Centre of Excellence for Risk Assessment (ACERA) has improved and tested some existing methods for obtaining and using expert opinion. Here we discuss two of these techniques: the 'elicitation tool' and 'point-of-truth calibration' (PoTCal). The elicitation tool takes a prospective view of risk assessment: it uses structured techniques to elicit quantities and model structures for risk assessment. PoTCal calibration uses a retrospective approach: experts are asked to provide opinions about an outcome based on a variety of scenarios, characterised by several risk attributes. The contributions of the risk attributes to the final outcome are then back-calculated in a way that is consistent with the experts' collective beliefs. Both techniques can help experts make well-calibrated and consistent risk assessments.

Problems with expert opinion

We classify the problems with using expert opinion into three broad classes. First, individual opinions are subjective. People use modes of thinking and rules of thumb (heuristics) that are susceptible to a range of context, framing, cognitive and motivational biases (see Burgman 2005 for a review). An example of such a bias is 'anchoring', defined as the strong tendency of people to use an existing value as an anchor and adjust up or down from this value (Tversky and Kahneman 1974).

Second, in group settings, people are often intimidated by dominant figures and may fail to express their opinion. This can lead to one opinion dominating others. A well-studied example is the so-called halo effect, which refers to the tendency of people to make global assumptions about others based on a limited amount of information. People who are confident, articulate and authoritative are seen as credible, even though these characteristics may have little bearing on their domain expertise (Nisbett and Wilson 1977).

Finally, it is difficult to survey a large number of people to obtain opinions about all the risk attributes that contribute to an assessment. It is also difficult to summarise a range of diverse opinions to give a consensus or modal view that is consistent with both individual risk attributes, and also with the boundaries of a risk problem—such as the overall level of risk.

The ACERA elicitation tool reduces the effect of individual and group biases on risk assessments based on expert opinion; PoTCal calibration is principally concerned with the last problem—the efficient and consistent representation of diverse opinions.

Elicitation tool

The elicitation tool uses structured workshops that follow a DELPHI format, first developed by the RAND corporation in the 1950s (Rowe and Wright 200l; Burgman 2005), and special procedures to minimise the impact of heuristics and biases on the data gathered. It improves the quality of expert judgments compared to those derived using naïve or unstructured approaches. To date, it has been used in a number of workshops including a trial of an import risk assessment process, and to investigate the potential spread of livestock diseases in Australia.

In many circumstances, the DELPHI format can substantially improve the quality of expert judgments compared to those elicited using unstructured techniques (Rowe and Wright 2001). As implemented in the elicitation tool, the format requires the participants to provide individual judgments, then review and discuss one another's estimates, and finally make a second, private estimate. A refinement included in the elicitation tool is that it seeks to set bounds on key quantities—such as the probability that a pest or disease will enter a country by some particular route. Bounded or interval estimates are useful in risk assessments because they include information on both the location of an estimate and its uncertainty. For example, a statement that someone is 180 cm tall is a 'locational' estimate of height; a statement that someone is between 150 and 210 cm tall gives the approximate location but also indicates that there is a great deal of uncertainty.

One problem with interval estimates is that they are prone to considerable overconfidence—when asked about a quantity, most people provide narrow intervals that do not fully reflect their uncertainty (Soll and Klayman 2004). To reduce this effect, the elicitation tool uses the four-step question format outlined in Figure 1. Note that the interval need not be symmetric. People will often have more confidence in a lower or upper bound, and so the realistic estimate is closer to the lowest or highest estimate.

The questions asked during the workshops are designed to reduce bias, minimise some kinds of uncertainty, and accurately reflect residual uncertainty in the final intervals. Three types of uncertainty are targeted during elicitation:

1. *Uncertainty due to language*: This refers to misunderstandings or multiple interpretations of questions. To reduce this effect, questions are carefully worded so that there is little scope for multiple interpretations, and participants discuss the questions to remove vague, ambiguous and poorly specified terms, to arrive at a clear, shared interpretation of words and underlying assumptions.
2. *Uncertainty due to lack of knowledge*: The elicitation tool finds intervals that reflect each expert's lack of knowledge about a fact. The process includes feedback discussion, during which participants can provide arguments to support their estimates. Those with relatively little knowledge about a particular question can adjust their estimates if they hear credible alternatives. The expert's intervals capture the truth about as often as they should, meaning the experts are well calibrated.
3. *Uncertainty due to natural variation*: Some questions relate to issues for which there is no single 'fact of the matter', but rather a quantity that varies in space and time. For example, if a question seeks knowledge of the annual variation in, say, the number of animal movements into a

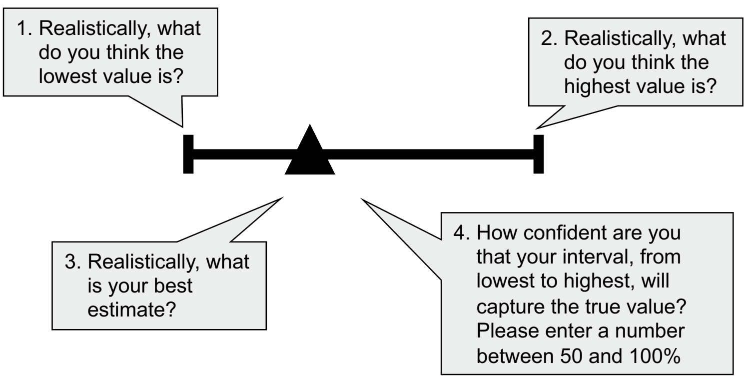

Figure 1. The four-step question format used in the ACERA elicitation tool (modified from Speirs-Bridge et al. 2010)

saleyard, a knowledgeable group could be asked for an interval estimate of expected variation of this quantity.

Just as the four-step question format helps reduce overconfidence, the DELPHI process—under the direction of an effective facilitator—aims to reduce the anchoring and halo effects often associated with expert panels. In addition, the DELPHI format helps to alleviate the effects of group-think (Janis 1982) and power differences between individuals.

Complete documentation of the elicitation tool—and software to support the process—is provided at ACERA's website (www.acera.unimelb.edu.au).

The reason for using the elicitation tool is that judgments derived by the technique—when tested using known facts—are typically more precise (they have a narrower range of uncertainty) and more accurate (less biased) than those derived from the most knowledgeable expert in a group of participants. The processes may be deployed in a range of situations, ranging from four people in a single office, to face-to-face facilitated workshops, to 20 or more experts distributed around the country, linked by telephone and the web. The improvements in calibration and accuracy are consistent, irrespective of the situation in which they are deployed. Once people are used to the system, it takes no more time or resources than are required for naïve or unstructured elicitation processes, and may even save time by improving the efficiency of interactions and improving group confidence in the results.

Point-of-truth calibration

Elicitation procedures and expert panels are often used for those risk assessments that are based on an analysis of the pathways by which a pest or disease can enter a country—especially where there is a relatively simple sequence of steps leading from entry of a pest to dispersal in another country. Where there are multiple pathways and a range of attributes that can affect outcomes, scoring systems are more commonly used for risk assessment. A well-known example is the Australian weed risk assessment system (Pheloung et al. 1999), which has also been applied in Europe (Crosti et al. 2010; Gassó et al. 2010), the United States (Gordon et al. 2008a) and elsewhere (Gordon et al. 2008b). Most scoring systems integrate information about variables (risk attributes) into a single risk score suitable for decision-making. The construction of scoring systems, however, is often criticised as being arbitrary as there is no transparent basis for the selection of weighting and integration of individual risk attributes. It can also be tedious to survey panels of experts when there is a large number of risk attributes to consider. PoTCal is an alternative to scoring systems based on expert judgments on constructed risk scenarios rather than individual scores of risk attributes.

PoTCal is a general regression approach akin to the choice modelling techniques used in economics (Bennett and Blamey 2001). Experts are individually surveyed using a questionnaire that seeks their views on the likely outcomes of complex scenarios. Each scenario is characterised by risk attributes, which are provided in varying levels and combinations. For example, a questionnaire for a weed risk assessment might have an outcome such as 'the probability of establishment in the next 10 years' and each scenario might concern a single weed and include attributes such as the current geographic range, the tolerance to herbicides, and the ability of field observers to detect the plant or seeds.

When the experts have provided their opinions on the outcome (or likelihood of an outcome) for each scenario, various kinds of general regression techniques can be used to estimate the contributions of the risk attributes. Modern regression allows modelling of potentially nonlinear relationships between attributes and outcomes, estimates the size of effects according to the evidence provided by the experts, and adjusts for interactions among attributes—thereby eliminating the arbitrariness of the scoring systems. The name reflects the fact that experts provide a point of truth (opinion about an outcome) and that the effect of risk attributes are calibrated within the modelling process so that their net effect best reflects each point of truth.

PoTCal is a rigorous method for weighting risk attributes, but is also an efficient method for elicitation. For n scenarios, experts provide just n opinions. If, instead, they were asked to provide opinions on the importance of m individual attributes, they would need to consider all m attributes in all possible scenarios ($>n$). They would also need to provide explicit opinions about weights and interactions to approach the predictive power of the PoTCal approach.

Our experience across several studies is that subject-matter experts readily accept PoTCal surveys and provide high return rates. To date, the technique has been used for prioritising weeds for eradication (Cunningham et al. 2003), predicting the cost of the eradication of marine pests (Knight et al. 2007; Crombie et al. 2008) and identifying significant range extensions of invasive marine pests (Derbyshire and Caley 2009). In each of these studies, the elicitation burden was relatively small, and the outcome was a practical expert system that has been used for making decisions about weeds or pests.

The particular advantages of PoTCal over expert-based scoring systems are set out below (Barry and Lin 2010):

1. It is more straightforward for experts to consider scenarios rather than risk attributes that are dependent on individual mathematical modelling. It only needs a single elicitation of the risk of the scenarios under assessment, and therefore the elicitation is direct and transparent.
2. Assessment of scenarios allows the expert to apply all of their knowledge about the scenario, and uncertainties in the ability to assess risk can be quantified in the analysis.
3. Variations between experts can be quantified and incorporated into decision-making.
4. It avoids experts having to consider formulation of complex interactions between individual risk components and/or attributes.
5. Using modern statistical or machine-learning methods such as regression or classification trees means that the weights are automatically calibrated to real-world scenarios.
6. It forms a logical bridge to traditional regression-based approaches to scoring when data are available.
7. The method provides consistent results derived from expert judgments.

Conclusions and implications

The two techniques for expert elicitation have different purposes. The elicitation tool is best suited to group activities and for assessments where a pathway or some other well-defined series of events can be described so that individual probabilities or quantities can be estimated and combined in agreed ways. PoTCal calibration works best with independent experts and is better suited to complex scenarios where there is no agreed pathway or understanding of the ways in which outcomes arise.

The outcome of either technique is a distillation of expert opinion rather than an objective or empirical evaluation. Neither technique replaces the need to measure and gather evidence to support biosecurity decisions, but both have proved useful for making biosecurity decisions in Australia when 'hard' evidence is not available, or is limited in scope.

Gathering, summarising and adequately representing opinions is always done in a specific social and cultural setting and is influenced by the particular psychology of experts and investigators. Hence, direct application of techniques developed in a specifically Australian context is unlikely to be directly transferable elsewhere. Nevertheless, the techniques can help to make speedy and broadly acceptable biosecurity decisions, and so should be tested and, if found useful, adapted for use in the more diverse cultural environment of South-East Asia.

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A multiregion perspective on human and animal emerging infectious diseases

Ro McFarlane

Emerging infectious diseases (EIDs) affect society at many levels: as high-profile diseases of international concern due to their novelty or pandemic potential and as re-emerging or changing (and sometimes 'neglected') diseases that impact communities or regions. Although almost all diseases of livestock affect production, and can be viewed as an issue of food security, those diseases that are zoonotic create a further burden on livestock workers, their families and potentially the wider community. The high proportion of zoonotic EIDs from wildlife has called for a reappraisal of our management of wildlife and the natural environment, valued at our most pragmatic for its ecosystem services. EIDs vary in their impact in terms of morbidity, mortality, economics and community fear. Some EIDs may be as important as an early indication of ecosystem dysfunction (Cook et al. 2004).

This study focuses on EIDs of humans and animals in Australasia, South-East Asia and East Asia and explores patterns to assist integrating health and environment and improve biosecurity. The Australasian – South-East Asian – East Asian regions (defined by country in the following paragraph) is thought to be the epicentre for EIDs, in particular for zoonoses and vector-borne diseases (Wilder-Smith 2009). Dramatic social and environmental changes responsible for these EIDs include rapidly increasing human population, urbanisation, migration, chronic immunosuppression related to HIV/AIDS, malnutrition and poverty, globalisation and trade, agricultural expansion and intensification, and loss of natural habitat. In this short presentation it is not possible to expand on any of these concepts; instead, a brief summary of diseases relevant to the Greater Mekong Subregion (GMS) is presented and some aspects of wildlife interaction and land use are highlighted to introduce the major themes. This project is not yet completed so it should be viewed as a work in progress.

Methods

A systematic review of literature (1973–2010) based on the key words 'emerging infectious disease(s)' and 'emerging communicable disease(s)', and by region and country (as below) using databases Scopus, CAB and Web of Science was used to document human and animal EIDs in Australasia (Australia, Fiji, New Zealand, New Caledonia, Papua New Guinea and Solomon Islands), South-East Asia (Burma, Brunei, Cambodia, Indonesia, Lao PDR, Malaysia, the Philippines, Singapore, Thailand, Timor-Leste and Vietnam) and East Asia (China and Hong Kong, Japan, Korea and Taiwan). Additional information was sought from national and international reports.

A list of emerging and re-emerging infectious diseases meeting the definition presented by the United States Institute of Medicine (Morse 1995) was compiled, and information on the disease, its pathogen(s), host(s), distribution, environment/land use and causality as discussed in the literature was recorded. Themes relevant to environmental determinants of EIDs, specifically biodiversity and land transformation, are explored in detail in a case study of the clustered emergence of three infectious diseases from bats on the east coast of Australia in the 1990s. The case study is not discussed further in this presentation. A subset of the data specifically relating to the GMS (Burma, Cambodia, China, Lao PDR, Thailand and Vietnam) was extracted from this database and is presented here.

Results

Systematic literature review

The review included 806 papers. Australia, China, Hong Kong, Japan and Taiwan had more than 100 papers; Indonesia, Korea, Malaysia, New Zealand, Singapore, Thailand and Vietnam had 30–99 papers; and the other countries had fewer than15 papers.

The four diseases that were most commonly the primary subject of the literature were SARS-coronavirus (125 papers); avian influenza (49); chytridiomycosis, an amphibian pandemic driving species extinctions (20); and HIV/AIDS (18). Human diseases were discussed most frequently and wildlife diseases rarely, except in Australia and New Zealand where the presence of national wildlife health networks augmented the peer-review literature. Information was collated on 53 EIDs of domestic animals and livestock (including aquaculture species), 120 EIDs of humans and 25 diseases of wildlife. A summary of EIDs of domestic animals and livestock (Table 1) and of humans (Table 2) associated with the GMS is presented.

Diseases of livestock and domestic animals

EIDs of livestock (n = 53) were predominantly hosted by multiple species including wildlife (n = 29). There were also single-species diseases (n = 16) with a small number of vector-borne and food-borne diseases. Pigs and aquaculture species (primarily shrimp) dominated the literature.

A total of 20 EIDs of livestock and domestic animals were of, or overlapped, the GMS (Table 1). These include diseases of pigs (n = 8), shrimp (n = 5), fish (n = 1), other hoofed livestock (n = 4) and domestic carnivores (n = 2). Five of these diseases were zoonotic as well as significant production diseases (avian influenza, *Streptococcus suis* (serotype 2 ST7), porcine eperythrozoonosis and trichinellosis).

For all regions, livestock intensification was the major mechanism described, followed closely by quarantine failure (including illegal animal importation) and then habitat modification. Cultural practices (e.g. fertilising fields with raw sewerage and cohabiting in close association with poultry and pigs) assisted selection or mutation of new organisms. In the GMS, the aquaculture and pig-production diseases were linked to intensification of production, although the re-emergence of trichinellosis in China is associated with the proliferation of small farms in urban and peri-urban areas (Cui et al. 2006).

Diseases of wildlife

In Australasia—specifically Australia and New Zealand—quarantine failure and habitat disruption were the principal mechanisms of causality. Some information on the health of wildlife in the Mekong could be found in the avian influenza literature (Tiensin et al. 2005) or as serosurveys for pathogens of interest (e.g. serological evidence for Nipah virus and Australian bat lyssavirus in *Pteropus lylei* in Cambodia and Thailand) (Olson et al. 2002; Lumlertdacha 2005; Wacharapluesadee et al. 2010).

Diseases of humans

EIDs of humans (Table 2) were grouped as:

- human only, ‘single-species’ diseases (including antibiotic-resistant strains of bacteria, new strains of existing viruses and novel diseases associated with chronic immunosuppression) and vector-borne diseases
- zoonotic diseases of domestic or wildlife origin
- zoonotic vector-borne diseases (all from wildlife)
- zoonotic food-borne diseases and sapronoses
- diseases of environmental origin.

The majority of these were zoonotic, predominantly from wildlife (63%).

Within the GMS, zoonotic diseases made up 70% of the EIDs, although wildlife comprised a smaller number of these (51%). Food-borne diseases were from mixed livestock sources (3), cattle (1), pig (1), poultry (1), carnivore (1), shellfish (2) and multiple fish parasites (incompletely described). Diseases from wildlife were overwhelmingly of rodent origin (n = 9, one of these required—and five others commonly involved—commensal species such as *Rattus norvegicus,* the remainder were common agricultural species), but also from primates (n = 2, both macaques) and carnivores (n = 3, predominantly cats and dogs, domestic or wild). Only one disease of bat origin, SARS-coronavirus, was recorded. Other species include the near-commensal Asian house shrew *Suncus murinus* and, less species-specific, deer, rabbit and waterbirds.

Causality is discussed in general terms in the literature. In South-East Asia, human behaviour—including cleaning and cooking preferences—is the most common mechanism for emergence discussed, followed by microbial selection or mutation (particularly for resistant strains of microbes) and increased human susceptibility (largely as a result of HIV/AIDS but also due to population growth). This is followed by habitat disruption, urbanisation, livestock intensification, quarantine failure, wildlife trade and climate change, respectively. The pattern is similar for East Asia, with more emphasis on livestock intensification and habitat disruption; the latter is the most commonly expressed causal mechanism in Australasia.

Table 1. Emerging infectious diseases of domestic animals and livestock, Greater Mekong Subregion

Name	References	Type	Pathogen	Primary hosts	Regions	Emerging in GMS
Classical swine fever/hog cholera	Westbury 2000; Zhu et al. 2009; daff.gov.au	D-SS	Virus +ssRNA	Pig	Australasia, South-East Asia, East Asia	China (new virus genotypes) 1990s
Porcine reproductive and respiratory syndrome	Tong et al. 2007; Zhou et al. 2008	D-SS	Virus +ssRNA	Pig	South-East Asia, East Asia	China 2006, Vietnam 2007
Post weaning multisystemic wasting syndrome	Kawashima et al. 2002; FFTC 2003; Staebler et al. 2005; Zhou et al. 2006; Truszczynski and Pejsak 2007	D-SS	Virus ssDNA	Pig	South-East Asia, East Asia	China, Thailand 1993
Porcine dermatitis and nephropathy syndrome	FFTC 2003	D-SS	Unknown	Pig	Australasia, South-East Asia, East Asia	China, Taiwan 1993
Streptococcus suis serotype 2 ST7	Ye et al. 2006; Ho Dang Trung et al. 2008	D-SS	Bacteria	Pig	South-East Asia, East Asia	Vietnam 2007; Thailand (other strains); Sichuan, China, Hong Kong 2005
Goatpox; capripoxvirus	Babiuk et al. 2008	D-SS	Virus dsDNA	Goat	South-East Asia	Vietnam 2005, 2008 (Chinese strains)
Porcine eperythrozoonosis (*Eperythrozoon suis*)	Yang et al. 2000; Wu et al. 2006	D-SS	Bacteria *Rickettsia*	Pig	East Asia	China 1991
Trichinellosis	Dupouy-Camet 2000; Cui et al. 2006	D-MSW	Parasite	Pig, rodents, dog	Australasia, East Asia	China 1990s
Foot-and-mouth disease virus serotype O	Knowles 2005; Suguira et al. 2006	D-MSW	Virus +ssRNA	Multiple species	South-East Asia, East Asia	China 1999; Burma, Lao PDR, Thailand, Vietnam 1999–2000
Highly pathogenic avian influenza H5N1	Sugiura et al. 2006	D-MSW	Virus –ssRNA	Poultry and aquatic	South-East Asia, East Asia	China 1996, Vietnam 2003, rest of South-East Asia 2003–04

Table 1. (continued)

Name	References	Type	Pathogen	Primary hosts	Regions	Emerging in GMS
Neospora caninum	Kim et al. 2002	D-MS	Protozoa	Dog, cattle, water buffalo	Australasia, South-East Asia, East Asia	Thailand 1998, Vietnam 1999, China 2007
Rabies	Sugiyama and Ito 2007; www.who.int	D-MSW	Virus –ssRNA	Domestic dog	South-East Asia, East Asia	China; Vietnam expanding
Canine parvovirus 2, 2a, 2b	Dobson and Foufopoulos 2001; Ikeda et al. 2002	D-MSW	Virus ssDNA	Wild and domestic dog	Australasia, South-East Asia, East Asia	Widely established. Australia/Japan from 1978 ‘global’
Hepatopancreatic parvovirus	Bonami et al. 1995; Fauce et al. 2007	D-MSW	Virus ssDNA	Shrimp	Australasia, South-East Asia, East Asia	Thailand from 1984, China 1985
Infectious hypodermal and haematopoietic necrosis virus	Wang et al. 2006	D-MSW	Virus ssDNA	Shrimp	Australasia, South-East Asia, East Asia	China 1996
Yellow head virus	Wang et al. 2006	D-MSW	Virus +ssRNA	Shrimp	South-East Asia, East Asia	Thailand 1990, rest from 1992
Taura syndrome virus (shrimp)	Wang et al. 2006	D-MSW	Virus ssRNA	Shrimp	South-East Asia, East Asia	Taiwan, China 1998; Burma, Thailand, Vietnam 2003
White spot syndrome virus	Wang et al. 2006	D-MSW	Virus dsDNA	Shrimp	South-East Asia, East Asia	China 1993, Thailand 1994, most by 1996
Koi herpes virus	Ishioka et al. 2005; Miyazaki 2005	D-MSW	Virus dsDNA	Koi and common carp	South-East Asia, East Asia	Indonesia, Thailand 2004; Japan, Taiwan

D = disease of domesticated animal or livestock; dsDNA = double-stranded DNA; GMS = Greater Mekong Subregion; MS = multiple host species; MSW = multiple host species including wildlife; SS = single host species; ssDNA = single-stranded DNA; +ssRNA = positive-sense single-stranded RNA; –ssRNA = negative-sense single-stranded RNA

Table 2. Summary of emerging infectious diseases of humans in the Greater Mekong Subregion derived from a systematic review of literature, 1973–2010

Human (single-species) diseases and disease-causing agents • HIV/AIDS • Tuberculosis-MDR (*Mycobacterium tuberculosis*) • Hepatitis C • Coxsackievirus A24 variant • Hand, foot and mouth disease (enterovirus 71) • Rotavirus G9 serotype • Rotavirus G4P6 • Rotavirus G9 • Adult diarrhoea rotavirus (rotavirus group B) • Metapneumovirus **Vector-borne diseases and disease-causing agents** • Malaria • Dengue virus • Seadorna virus • Chikungunya **Zoonoses associated with wildlife** • Plague (*Yersinia pestis*) • Alveolar echinococcosis (*Echinococcus alveolaris*) • *Penicillium marneffei* • Leptospirosis • Schistosomiasis (*Schistosoma japonicum*) • SARS-coronavirus • Hantavirus with renal syndrome: Hantaan virus • Hantavirus with renal syndrome: Thailand virus • Hantavirus with renal syndrome: Thottapalayam virus • Hantavirus with renal syndrome: Seoul virus • Angiostrongyliasis (rat lungworm) • Zika virus **Zoonoses associated with domestic animals** • *Streptococcus suis* serotype 2 ST7 • Hookworm (*Necator americanus*) • Influenza A H1N1 (‘swine flu’) • Rabies • Highly pathogenic avian influenza H5N1 (‘bird flu’) • Porcine eperythrozoonosis (*Eperythrozoon suis*)	**Zoonotic vector-borne diseases and disease-causing agents** • Tularaemia ‘rabbit fever’ • Visceral leishmania • Macaque malaria (*Plasmodium knowlesi*) • Flea-borne typhus (*Rickettsia felis*) • Japanese encephalitis virus • Me Tri virus • Human granulocytic anaplasmosis (HGA) **Zoonotic food-borne diseases and disease-causing agents** • *Cronobacter sakazakii* • *Campylobacter* (fluoroquinolone resistance) • Extended-spectrum beta-lactamase producing gram-negative bacteria • EAEC—enteroaggressive *Eschericia coli* • STEC/VTEC—shigatoxigenic/verotoxigenic *Eschericia coli* • *Salmonella* Enteriditis • *Vibrio parahaemolyticus* O3:K6 • *Vibrio vulnificus* • Trichinellosis • Cysticercosis (*Taenia solium*) • Cryptosporidiosis (*Cryptosporidium parvum*) • Toxoplasmosis • Fish-borne trematodes • Hepatitis E **Diseases and disease-causing agents of environmental origin** • *Vibrio cholerae* 0139 Bengal • Human pythiosis (*Pythium insidiosum*)

Discussion

The literature, as a source of EID data for this project, is biased towards developed countries as a result of their higher research output (this study; Jones et al. 2008). It is also biased by topical diseases as seen in the high proportion of papers on aspects of the SARS-coronavirus pandemic, and is biased towards human diseases. Countries may lack the resources to investigate and process animal (and human) health into timely annual provincial and national reports (e.g. for the Food and Agriculture Organization of the United Nations [FAO] or the World Organisation for Animal Health [OIE]) so mining literature for reports and discussions of EIDs has merit, as does seeking in-country expert opinion by questionnaire (Wilder-Smith 2009).

With zoonotic diseases, particularly those of wildlife origin, such a major theme in EIDs, it is important to understand the types of wildlife involved and how they are affected by human activities. Health and disease of wildlife should also be understood and this may command a higher priority in the future for researchers and policymakers. The number of species of wild and domestic animals involved in EIDs of humans and domestic animals are relatively few (n = 41). These are predominantly species that exploit human-modified environments (87%). This is also the case in the subset of information concerning the GMS.

The number of wild mammals in the GMS countries are displayed by taxonomic order in Figure 1 as total species, threatened species, those that are the subject of hunting and trade, and those that are recorded in all human-modified environments (collectively, disturbed secondary forest, agricultural landscapes and urban regions) and in urban regions only (IUCN 2010). The figure shows the relatively small number of wildlife that are in residential and occupational contact with humans, the vast number hunted in some part of their range within the GMS countries and the sobering proportion of threatened species. Hunting, trade and consumption of wildlife ('bushmeat') has been considered an important driver of EIDs (Webster 2004; Wolfe et al. 2005) and is also the second most important driver of biodiversity loss after habitat destruction (IUCN 2010). The primary driver of biodiversity loss is loss of habitat: those species that cannot adapt to use the ever-expanding human-modified environments are at risk of decline.

Rather than wildlife being a potentially infinite source of zoonotic pathogens, we can instead consider which wildlife species can accommodate humans and domestic animals, and potentially share their pathogens. The odds of wild mammal hosts that live in a human-modified environment being the source of EIDs are approximately 15 times higher than that of wildlife not living in a human-modified area. Which mammals these are is determined largely by the resources represented by different extractive, agricultural and residential land uses within or adjacent to the natural distribution of the species (i.e. it is location specific and defined by land use and is anticipated to alter further with climate change [Foden et al. 2008]). It also includes introduced or invasive species. Adaptive species exploiting these opportunities may be of reduced diversity but have increased number of individuals (Meade and Earickson 2000).

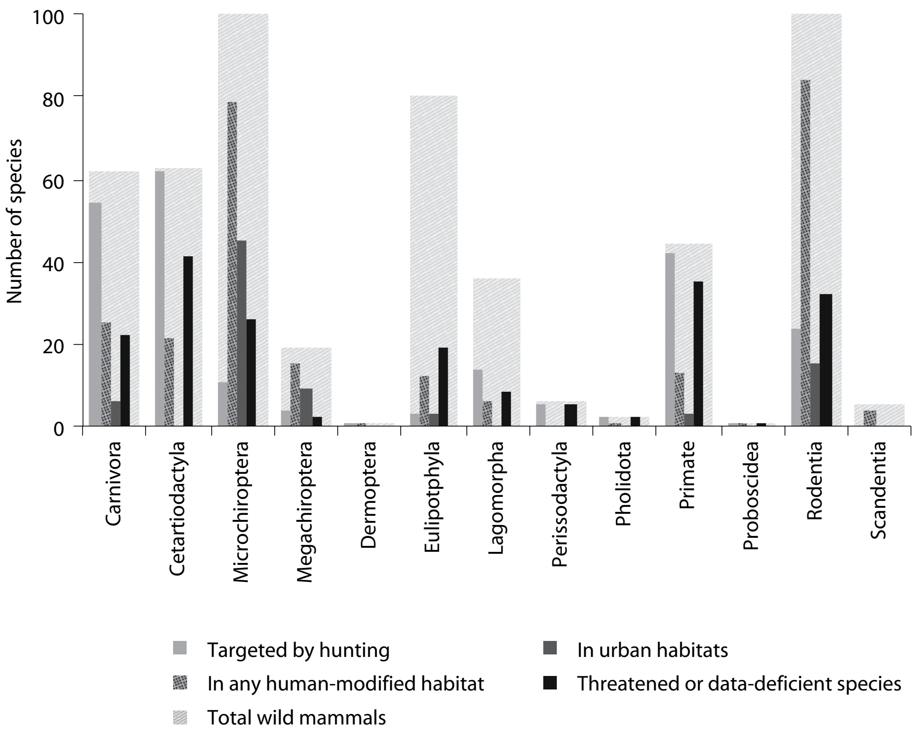

Figure 1. Wild mammals of the Greater Mekong Subregion (Burma, Cambodia, China, Lao PDR, Thailand and Vietnam). Source: IUCN (2010)

Where these overlap with high densities of humans (urban areas) and domestic animals or livestock (including intensive commercial production units), diseases with epidemic potential (i.e. reproductive number R_o>1) may increase.

Diseases affecting humans only are facilitated by densely populated urban areas and concentrations of susceptible people (e.g. hospitals, slums with poor sanitary conditions, schools). The sheer size of urban centres has affected the location of rural enterprises, particularly where regional transport infrastructure is poor (Slingenbergh et al. 2004). The proximity of intensive livestock agriculture to markets (predominantly towns and cities), the disposal of by-products and the growth of urban and peri-urban livestock to address urban poverty (Ghirotti 1999) has shifted the focus of some traditional zoonotic diseases into the urban/peri-urban zone (e.g. alveolar echinococcus [Eckert et al. 2000], leptospirosis [Yanagihara et al. 2007] and trichinellosis]). Where R_o<1, these diseases may be managed by environmental modification alone. Urban expansion has transformed previously highly productive land that once supported a high natural biodiversity. Remnant biodiversity competing with human interests can result in conflict and also zoonotic disease (Field et al. 2001). Different human populations—contemporary, traditional rural and indigenous—have features of social, cultural and religious identity relevant to the health of the population that are often location-specific (and possibly relocated) that continue as, or in spite of, the varied drivers of EIDs and the diseases themselves. This adds to the complexity of landscape-level disease risk but encourages the appreciation of health as a self-organising system not a tool box of component parts (Pearce and Merletti 2006).

The concept of 'unhealthy landscapes' is not a new one (Patz et al. 2004) and requires ongoing exploration at locality and disease level. Developing tools to identify risk based on the nature of the disease (including R_o) and land use (Arinaminpathy et al. 2009), and the multispecies communities, including wildlife, that use them can only go part of the way to achieving sustainable health. We need to safeguard areas to protect ecosystem services and work within conservative estimates of planetary boundaries (Rockstrom et al. 2009), retrofitting human activities if we are to start from a level playing ground. These issues are as relevant to the GMS as elsewhere.

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Patterns of livestock production, movement and trade

Cattle can be transported long distances between villages and to local markets. (Photo: Sieng Socheat)

Emerging production and market environment for livestock in the Mekong region: opportunities, challenges and the response

Vinod Ahuja

Much has been written about the spectacular growth and changing landscape of the livestock sector in Asia—the opportunities these changes offer and the new challenges they create. The region has generated more than half the gains in global livestock production since the early 1990s and this growth is expected to continue in the foreseeable future in view of the robust economic outlook and progressive urbanisation. The projected continued expansion of the demand for animal products will require substantial investment in improved efficiency of resource use, development of appropriate technologies and control along the value chain.

Asia is a diverse region with widely varying income levels, prospects for future economic growth, production and marketing systems, and technical and institutional capacities. This diversity is also reflected in the consumption and production trends of livestock products, the trading patterns and the aspirations of countries in meeting multiple needs from the sector. Although formal trade in livestock products is still modest as a proportion of consumption, there is sizeable and growing unofficial trade in live animals in the region, raising new challenges for sector governance in general, and design and implementation of measures to mitigate disease spread in particular. This is particularly so in countries that share extensive terrestrial boundaries, where the market forces are strong, and the institutional capacity to guide future sector growth is variable.

The Greater Mekong Subregion (GMS) represents one such geographical area. The region is characterised by countries sharing long and porous borders with close economic and cultural ties. There are substantial differences across countries in the production and marketing systems, institutional and political structures, and expectations of future economic growth. These linkages and differences are likely to further intensify already strong pressures for movement of livestock products and live animals, raising questions about the implications of sector growth in different countries for income generation, natural resource management and public health.

Production, consumption and trade trends

South-East Asia has been an active partner in the livestock revolution with annual growth rates in meat and milk consumption exceeding twice the global average since the early 1980s (Table 1). Production has responded to growing demand although falling short of consumption, resulting in growing imports (Tables 2 and 3). From 1980 until 2007, imports of meat grew more than five times and milk-equivalent imports nearly three times. Similar trends were observed in the GMS but with considerable variations across countries. Cambodia and Lao PDR continue to have very low-level consumption of animal-source foods despite relatively high growth rates since the early 1980s. Burma, Thailand and Vietnam emerged as the key producers and the production of pig and poultry in these three countries grew rapidly, displacing ruminants as a significant provider of animal protein. Thailand has a modern, large-scale, integrated poultry sector and is one of the major exporters of poultry and poultry products, whereas Vietnam has emerged as the main importing country with both

Table 1. Total consumption of meat and milk—Asia and the world

Region	Meat			Milk[a]		
	1980	2007	AGR (%)	1980	2007	AGR (%)
World	134.0	266.0	2.57	455.4	669.3	1.44
Asia	29.1	112.8	5.15	78.1	250.0	4.40
East Asia	19.1	80.7	5.48	13.1	54.3	5.41
China	14.7	71.5	6.03	3.6	41.1	9.44
South-East Asia	3.49	14.0	5.28	3.6	9.5	3.66
Burma	0.25	1.40	6.59	0.35	1.25	4.83
Cambodia	0.025	0.23	8.57	0.045	0.080	2.15
Lao PDR	0.03	0.11	4.93	0.014	0.028	2.60
Thailand	0.87	1.90	2.94	0.36	1.50	5.43
Vietnam	0.50	3.50	7.47	0.49	3.50	7.55
South Asia	4.49	9.49	2.81	47.3	147.8	4.31
India	2.57	3.80	1.46	31.9	102.2	4.41
Rest of Asia	2.02	8.61	5.52	14.1	38.4	3.78

AGR = annual growth rate
[a] Excluding butter

Table 2. Total production of meat and milk—Asia and the world

Region	Meat			Milk[a]		
	1980	2009	AGR (%)	1980	2009	AGR (%)
World	136.0	281.5	2.42	465.6	680.6	
Asia	28.6	116.4	4.96	69.9	250.8	4.51
East Asia	18.8	83.9	5.30	10.2	51.2	5.73
China	14.8			2.92		
South-East Asia	3.63	14.3	4.83	0.73	3.69	5.72
Burma	0.25	1.43	6.24	0.33	1.21	4.57
Cambodia	0.02	0.21	7.67	0.01	0.02	1.74
Lao PDR	0.03	0.10	4.42	0.003	0.007	3.00
Thailand	0.89	2.13	3.05	0.03	0.84	12.2
Vietnam	0.49	3.47	6.95	0.04	0.31	7.19
South Asia	4.61	12.4	2.98	46.4	124.3	4.33
India	2.62			31.5		
Rest of Asia	1.56			12.6		

AGR = annual growth rate
[a] Excluding butter

milk and meat imports increasing several-fold. Vietnam, Thailand and China have also experienced considerable structural changes in the poultry sector.

Data on production and trade of feed is not as readily available as meat and milk, but there are clear indications of rapidly growing imports of concentrated poultry feed in the region. There are also reports of feed manufacturers shifting production from poultry to pigs due to lessening demand for poultry feed in the wake of recent highly pathogenic avian influenza outbreaks. This is likely to spur structural changes in the pork industry, especially in China and Vietnam. Indeed, given the likely limits to technical change in broiler production, the swine industry in Asia could emerge as a key competitor to poultry, competing heavily for compound feed and ingredients—corn, soybean and fats.

Consistent projections on country-level production of different types of animal products are hard to find, but regional projections from international

Table 3. Net imports of meat and milk—Asia

Region	Meat		Milk-equivalent	
	1980	2007	1980	2007
Asia	1268.1	6331.3	9475.7	17565.8
East Asia	397.2	4356.2	2153.7	5299.3
China			491.0	1745.9
South-East Asia	62.4	314.2	2634.1	7109.6
Burma	0.0	0.3	32.2	124.9
Cambodia	0.0	0.5	24.1	55.3
Lao PDR	0.0	0.0	9.1	43.2
Thailand	–18.7	–497.6	286.8	667.7
Vietnam	1.1	155.1	41.7	840.4
South Asia	125.3	–398.9	1730.0	886.4
India	–51.9	–497.6	344.9	–519.5

organisations, including the Food and Agriculture Organization of the United Nations (FAO), the Organisation for Economic Co-operation and Development, the United States Department of Agriculture, the Food and Agricultural Policy Research Institute, and the International Food Policy Research Institute, and industry reports suggest that the production and consumption of meat and milk in the region will continue to grow, albeit at a slower pace than in the past.[1] China and Vietnam will emerge as key importing nations and the trade position in feed will likely worsen. According to some forecasts, China is expected to double its corn production between 1997 and 2025 and yet import approximately 40 million tonnes of corn to meet the growing demand. This could put upwards pressure on corn prices, especially as demand also intensifies in the United States for ethanol production. This could also result in other cereals—such as wheat—being used as feed (Falcon 2008). It is difficult to predict how that will affect the competitiveness and political economy of the region's agriculture and livestock sector.

Data on trade on live animals is scant and unreliable. As noted earlier, the formal trade in live animals and livestock products is small but there is sizeable informal trade in live animals across the region. Recent studies have provided more credible information on the overall directions of livestock movement as well as the actual market chains and stakeholders involved in the cross-border movement of livestock. For example, a study by the FAO, Asian Development Bank and World Organisation of Animal Health (OIE) South-East Asia Foot-and-Mouth Disease Campaign (SEAFMD) describes Cambodia and Laos as transit countries in terms of the movement of pigs and large animals from Thailand to high-value markets in Vietnam and China. Due to modest demand for meat in Cambodia, the country also exports some domestically produced large animals to Vietnam, whereas Laos is seen as a net importer while also serving as a transit country for large animals (see Kerr et al. 2012). These movements occur with minimal regulations and create new challenges for national authorities in designing and implementing measures to mitigate disease spread across borders. In addition, entrenched interests at several levels in the market chain impose additional barriers in effective international cooperation in managing this growing trade.

The special role of smallholders

In spite of the ongoing structural changes and scaling up of pig and poultry production, the majority of animal-source food in the region is still produced by small, semi-subsistence farmers. This means that expected future livestock sector growth in the region, especially in poor countries such as Burma, Cambodia and Laos, can potentially serve as a basis for enhancing the welfare of the rural poor. The international debate during the last two decades has been full of optimism that the 'livestock revolution'

1 Some country-level forecasts, especially for key producing nations, are available, but differences in forecast period and product coverage make it difficult to construct a cohesive and consistent picture for the GMS region as a whole.

could provide a new pathway out of poverty and a basis for increased support towards meeting food and nutritional security goals in developing countries. Although it was understood that the relationship between ownership of assets and market participation is not automatic, the hope was that governments would pursue that goal. More than two decades later, a recent paper by Dijkman (2009) notes that despite the opportunity, livestock has remained an 'expression' of decreasing poverty rather than a 'pathway' out of poverty.

The relationship between agricultural sector growth and poverty reduction is by now very well established. There is also some evidence that the elasticity of poverty reduction with respect to agricultural growth is higher in smallholder production systems than those dominated by a few large producers. Mellor (2004) argues that the relationship between poverty reduction and agricultural growth is indirect and relates to the local multipliers generated by prospering farmers spending their increased incomes on goods and services produced in the rural non-farm sector. In that context, a smallholder production system is likely to generate a more equitable distribution of the surplus which in turn creates a larger impact on the non-farm rural economy and ultimately on poverty reduction. Smallholder livestock production has a similar impact but makes a more immediate and direct impact on poverty and nutritional levels because additional income generated from livestock production is typically spent on increasing food consumption.

The academic argument to support and invest in smallholder livestock production remains as compelling as ever, but there appears to be continued scepticism in the region about the ability of smallholder and poor households to respond to complexities of the emerging market environment. At least part of this scepticism emanates from the perception that small-scale producers cannot be competitive with the larger operations that benefit from the economies of scale. Evidence, however, suggests that this may not necessarily be so. Studies in Brazil, India, the Philippines and Thailand on broiler, layer and pig production have shown that production-related scale economies are small once the transactions costs are accounted for and market-oriented smallholdings are relatively more profit efficient than medium-scale operations (Delgado and Narrod 2002). But smallholders do need to make higher profits per unit to survive because of lower volume.

Research to understand constraints in linking smallholders to markets in general has found the production-level constraints to be the least important; more important are the challenges of making efficient transactions between smallholder producers and the downstream players in the value chains. The only frequently cited constraining factor of production appears to be producer knowledge about market opportunities and the production techniques that would enable them to produce products acceptable to market. This requires institutional innovations to promote inclusion, investment in rural infrastructure, appropriate mechanisms for knowledge transfer and streamlining public service delivery systems to support small producers.

There are several examples in the literature where smallholder participation in expanding markets has been associated with higher levels of income and/or employment when supported by appropriate collective or network mechanisms. However, there are no specific patterns or models that can provide definitive guidance on how best to achieve similar outcomes in disparate environments. Searching for models that will work in specific circumstances will require a phase of 'trial and error' within specific social, economic, technical and organisational settings. But the probability of success in this search can be increased by nurturing processes and learning environments that would encourage internalising lessons from diverse experiences while at the same time discovering their own organisational designs to suit specific production, market, socioeconomic, political and cultural environments. In the absence of investment in these processes, the potential of the livestock sector to effectively, safely and equitably deliver on its objectives is likely to remain underexploited.

Conclusion

Rising consumption and production of livestock products in the Mekong countries have been associated with significant structural changes in the sector resulting in a growing dichotomy between smallholder producers and large-scale commercial operators. Although small producers still contribute the majority of animal-source food in the region, they face increasing risk of marginalisation from large operations with sophisticated technology and better access to growing markets. There is also growing pressure on the region's food-grain economy, with increasing use of grains in the diets of poultry, pigs and dairy animals.

East Asia and South-East Asia, including the GMS, have been at the helm of emergence and spread of animal—including zoonotic—diseases and food-borne contaminations. The region has also received increasing international attention and funds to battle trans-boundary diseases that have the potential to cause harm in more developed countries, both within and outside the region. While increased attention on prevention and control of diseases is in general a welcome sign, there is perhaps a need to find a more balanced approach towards disease control in the region, including adequate attention to (non-zoonotic) diseases of economic importance for the poor. At a more general level, there is a need to invest in the capacity of animal health services to better understand and exploit the roles of livestock and improved animal health for enhancing the welfare of the poor and minimising risks to livelihoods and human health.

These developments underscore the need to use resources more efficiently, to understand how production, health, environmental and livelihood goals complement each other, and to understand the trade-offs between them. Although each country will chart its own course, the international community would do well to facilitate investment in processes that stimulate learning environments, and partner with countries in their search for effective organisational models to maximise synergies and balance trade-offs in guiding future livestock sector developments in the subregion.

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Characteristics of livestock traders and trading in Cambodia

Socheat Sieng, Chris Hawkins, Ben Madin and James Kerr

Trans-boundary animal diseases, particularly foot-and-mouth disease (FMD) and classical swine fever (CSF, also known as hog cholera), limit production and invoke resistance by trading partners to the international movement of livestock and livestock products. Management of these diseases by traditional methods of checkpoints, movement permits and fines for unregulated movement of livestock tend to be counterproductive, resulting in further unregulated movements to avoid regulatory processes. In the absence of a national livestock identification system, tracking animals and their products is difficult and determining livestock movements within countries and between neighbouring countries is problematic. As part of an ACIAR-funded project (AH/2006/025: Understanding livestock movement and the risk of spread of trans-boundary animal diseases), discussion with livestock traders was initiated to determine the characteristics of trade and traders within Cambodia, and the nature of the interface between domestic and cross-border trade.

Current knowledge

Cattle numbers in Cambodia appear to be increasing, buffalo numbers are relatively static, while the number of pigs increased from 2000 to 2006 but have since decreased (Figure 1). Livestock production (excluding poultry) comprised about 11% of agricultural gross domestic product in 2005, equivalent to about US$158 million. Cambodia's trade is primarily with China, Thailand and Vietnam. Although there is trade with Lao PDR and Burma (Myanmar), available data suggest this is limited. The comparative advantage of live animal exports to China, particularly, is increasing (Hing et al. 2007).

However, statistics do not reveal the full extent of livestock (and other agricultural products) moving into and out of Cambodia, because much trade is unrecorded (Hing et al. 2007). With support from international organisations, the collection, compilation and reporting of agricultural and other statistics have improved in recent years (Hor 2008).

The World Organisation for Animal Health (OIE) has identified general directions of livestock into and out of Cambodia (Figures 2 and 3). While this is valuable in providing an overview of general trends in movements, it is not quantitative, does not indicate major movements and is only a static picture of movements at one point in time, whereas drivers of movement, and therefore movements themselves, change with season, feed availability and consumer demand for livestock.

In a world that is increasingly concerned with the spread of trans-boundary diseases, it is essential to understand livestock movements and the risks these pose to trade because of disease. Therefore, to support Cambodia's growing livestock export trade with Thailand, Laos, Vietnam and China, and in particular to protect Cambodia's markets, it is important to understand the people who facilitate the trade in livestock (ie. the traders), and the nature of that trade.

Livestock trade requires the movement of live animals and animal products. It has long been recognised that such movements are prime means for spreading disease, with rinderpest probably being the classic example (Scott 2000; Pastoret et al. 2006; Murcia et al. 2009). The ongoing challenges of controlling FMD and CSF (which are primarily spread by direct and indirect contact between livestock) require an understanding of livestock movements and how these can be influenced to reduce the risks of disease spread.

In Cambodia, susceptible livestock (cattle, pigs, buffaloes) are widespread in villages across the country and are used for transport, draught and food.

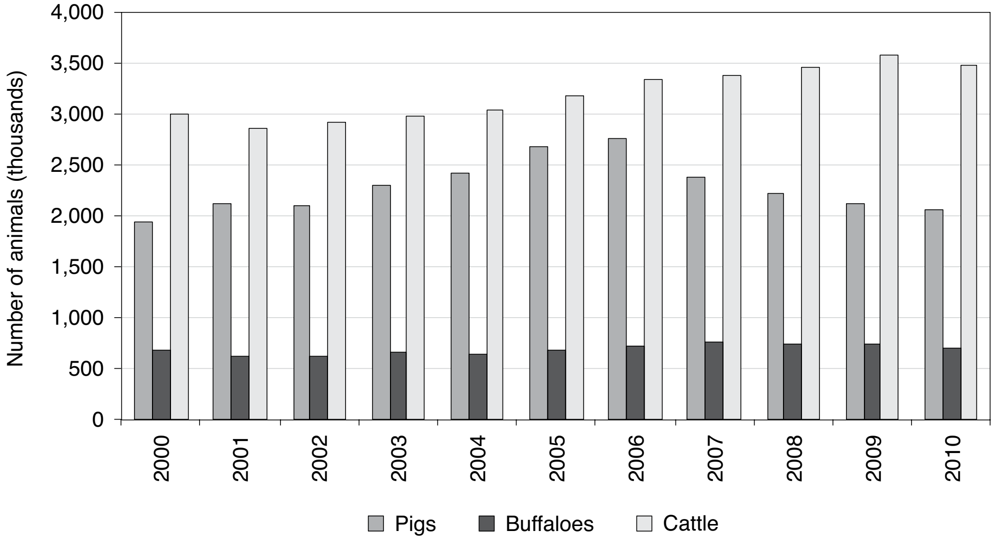

Figure 1. Livestock numbers in Cambodia—cattle, buffaloes and pigs, 2000–10. Source: MAFF (2011)

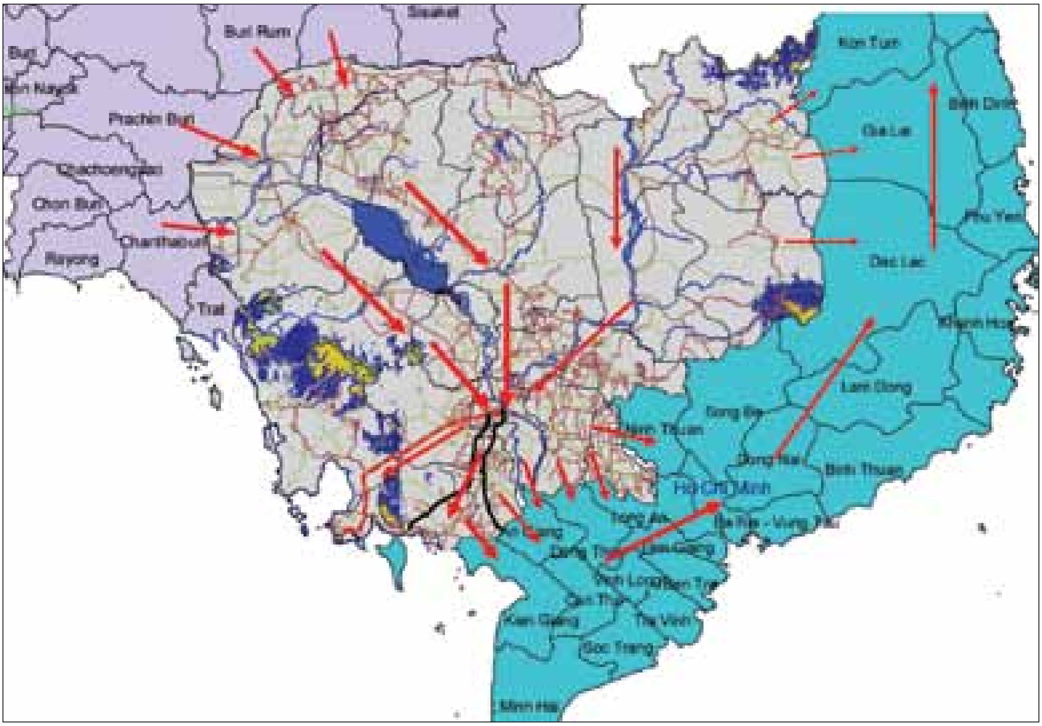

Figure 2. Movement of cattle in Cambodia and neighbouring Thailand and Vietnam, 2004. Source: Abila and Linchongsubongkock (2004)

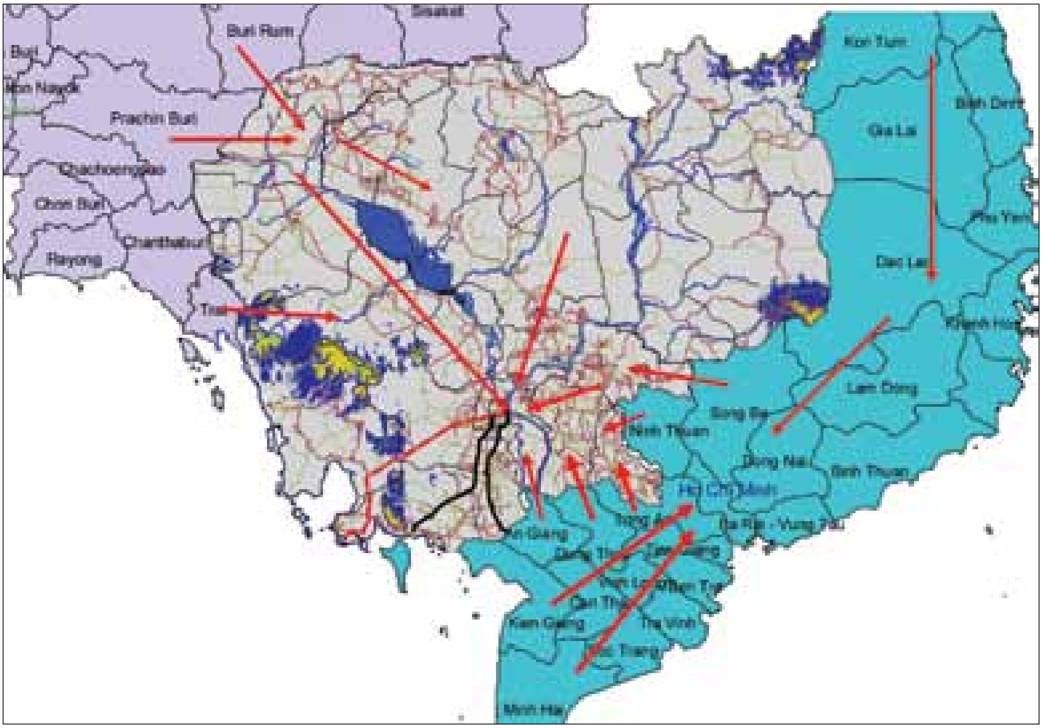

Figure 3. Movement of pigs in Cambodia and neighbouring Thailand and Vietnam, 2004. Source: Abila and Linchongsubongkock (2004)

Movements within the country occur on foot and by vehicle, with additional movements of cattle and pigs across national boundaries. Outbreaks of FMD are common (Gleeson 2002), and Cambodia is participating in the regional control of FMD through the OIE Regional Coordination Unit. The present study seeks to provide qualitative and quantitative data on livestock traders and their activities, with the view to developing non-legislative strategies to improve the safety of livestock movements within Cambodia and across national boundaries.

Methods

Traders are required to apply to the Cambodian Department of Animal Health and Production for permits to move livestock. From departmental records, regular traders operating in the Phnom Penh district, and Takeo and Kampong Cham provinces were identified and asked to participate in a survey by interview. Traders were selected on the basis of availability and willingness to participate. They were invited to a convenient location, and served refreshments before interviews. A small incentive payment (US$5) was provided to traders on completion of the interview.

Preliminary discussions were held with two groups of traders, to build rapport between them and project staff, to gain an understanding of their willingness to share information and to pilot the questionnaire.

The survey questionnaire was developed by project personnel, with input from sociologists at the Royal University of Cambodia. The questionnaire sought information about personal characteristics such as age, sex and education, but primarily sought details of trading, biosecurity practices, impact of regulations and factors that traders considered influenced their activities.

Interviews were held in Khmer by a bilingual veterinarian, who also translated findings into English and entered these into a computerised database for later analysis. Strict confidentiality was maintained for all interviews.

In the period September to December 2008, 60 traders were interviewed, with 20 from each of Phnom Penh, Takeo and Kampong Cham.

Analysis was basic, using frequency distributions; where comparisons were required, cross-tabulation or analysis of variance were used. Results are presented as overall outcomes, unless a specific group or province varied significantly.

Characteristics of traders

All but one trader were males. The only female trader was from Kampong Cham; she traded in cattle and was aged between 31and 40 years.

Age of traders is given in Table 1. This distribution was consistent across the three regions.

Table 1. Age of traders

Age range	Number (%)
20–30	8 (13)
31–40	23 (39)
41–50	17 (28)
51 and over	12 (20)

Educational level was evenly distributed between completion of grades 1–7 and grades 8–12. One trader advised that he had a college or university education.

Just over half (57%) were part-time traders who pursued other work for themselves (e.g. rice cultivation), or were involved in a small business or worked for another person. About one-third (32%) indicated that they were full-time traders, and 8% stated that they sometimes pursued other activities. Two respondents indicated that they were full-time rice farmers who occasionally traded livestock. A majority (77%) stated that they raised animals at home for consumption or to supplement family income. A decision to raise livestock was made independently of their trading business by 71% of respondents, whereas the other 29% said that raising stock was because of their trading business.

Most had been trading for several years, with 12 (20%) indicating that they had been trading for 3 or fewer years. Reasons given for being a trader were: family tradition (62%), a good source of income (48%) or encouragement to do so by others (17%). Of note was the sense by some (30%) that they had no other option. A clear majority (82%) indicated that they ran their business alone, without assistance from family members. Traders were evenly divided on whether they knew that a family member (e.g. a son) wanted to become a livestock trader.

Results

Trading practices

Cattle and buffaloes were the main animals traded (59%), with the remainder trading pigs. Of those trading cattle and buffaloes, 13 (22%) traded in cattle exclusively.

Annual estimates

Each year, an average of 519 (47–3,650) cattle, 88 (10–384) buffaloes and 1,840 (48–18,250) pigs were sold by traders. Volumes traded were heavily skewed towards the lower end of the range, with a small number of traders dealing in the larger numbers reported. Figure 4 shows the breakdown of trade by animal and quarter.

Trading was generally greater in the first half of the year ($P < 0.05$, Tukey's range test) for all species, although not as marked for pigs. Festivals in the early part of the year (e.g. Chinese and Cambodian New Year celebrations) may account for this. The percentage of buffaloes traded was markedly higher in the April–June quarter, but traders did not comment on the reasons for this. Drivers of this pattern need further elaboration; feed availability and the seasons may have an influence.

Traders recognised that the first half of the year was generally better for trading for all species, and offered reasons for this (Tables 2 and 3).

The predominant reasons given for the second half of the year being a more difficult time for livestock trade were generally the opposite of reasons given in Tables 2 and 3. However, traders did indicate that the rainy season (June to October) had some effect, and the involvement of both people and livestock in rice cultivation temporarily removed some suppliers and livestock from the market. Many pig traders (77%) believed that the high fish season adversely affected their trade. This indicates that consumers are substituting fish and pork at different times of the year. The reasons for this substitution may be price related, but further investigations are needed to determine whether there are specific social drivers, or whether it is simply a supply-and-demand issue.

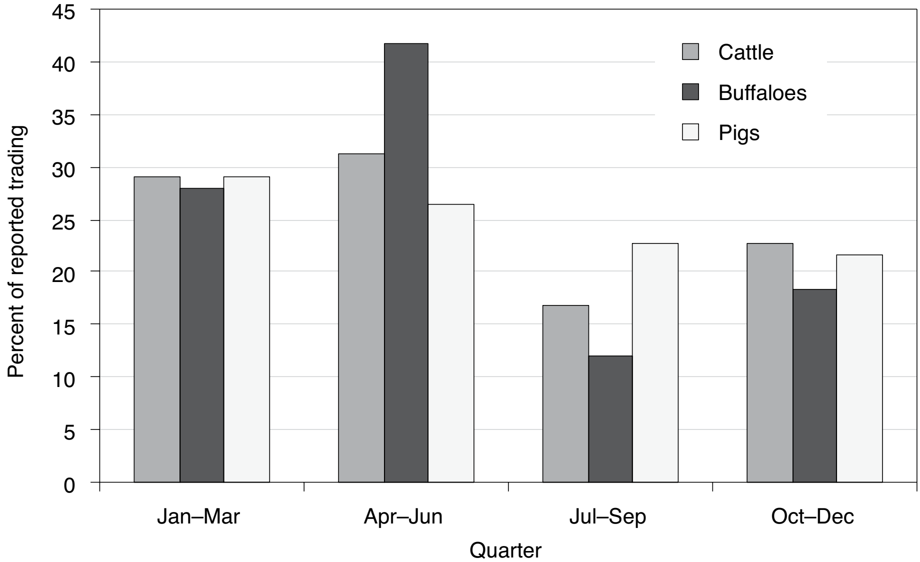

Figure 4. Trading of cattle, buffaloes and pigs in Cambodia by quarter, as reported by traders for recent years

Method of sourcing animals

Traders use a variety of means to obtain livestock for sale. Most commonly, stock is sourced from producers, either directly by travelling to known sources, or indirectly through phone contacts or family networks. An important way of finding stock for purchasing is to contact producers wanting to sell. This suggests a local supply network that traders develop as part of their operational strategy.

For the most part, traders obtain stock locally (within their home district or province), although all traders indicated that they will move beyond their provincial boundaries to obtain stock.

Finding buyers

Again, trader networks are the primary ways of locating buyers. These networks extend to other traders within Cambodia, and across the border into Vietnam (six traders, 10%). Information about local demand is circulated through local village networks. Some traders (eight, 13%) reported linkages with slaughterhouses and sold stock directly to these, and a small number (two traders, 3%) mentioned a specific company that they dealt with (Yuveak Peanik Company). Further discussion is warranted to determine the role played by bigger companies in the national and international movement of livestock.

Transport methods

Trucking was the main method of transport, with 77% of cattle traders and 69% of pig traders indicating transport by truck. A further 23% of cattle traders walked their stock to markets. Interestingly, about 58% of pig traders indicated that they also walk their pigs to markets, with 73% of pig traders also using motorcycles as transport.

On occasions, where roads were poor or non-existent, traders used boats to take cattle (four traders, 7%) and pigs (one trader, 2%) to Vietnam.

Time before sale and holding practices

About two-thirds (39) of traders sold their stock within a short time of purchase (several hours to a few days). This included virtually all the pig traders, who tended to trade locally. Transport of pigs was considered relatively inexpensive compared with cattle, but the cost of transport was not volunteered. Reasons given for this rapid onselling were to take advantage of good prices, and the concern that livestock could lose weight while waiting to go to markets.

Because of the higher costs involved in cattle transport, about one-third of traders hold their animals pending transport and sale. Holding areas included their own land, leaving stock with the original seller

Table 2. Major reasons given by traders for greater cattle/buffalo trading in the first half of the year

Reason	Percentage of traders indicating reason
High demand of meat markets	41
Farmer-preferred selling time	35
Higher sale price	32
Festive seasons	29
High demand from Vietnam	21
Low season for fish	18

Table 3. Major reasons given by traders for greater pig trading in the first half of the year

Reason	Percentage of traders indicating reason
Festive season	62
Low fish season	54
High demand of meat markets	31
High sale price	19

until transport was arranged, or using a third party holding area where animals could be kept until a full load was available. Traders sometimes share transport (i.e. to make up a load), but only if this was mutually beneficial (such as going in the same direction, or to the same market).

Destinations of livestock

Only two-thirds of traders responded to this question. Most of those who responded (25, 42%) delivered stock to slaughterhouses within their province and district, or to a slaughterhouse in another district but within their province. Other destinations included other farms in the district, locations in Phnom Penh, slaughterhouses in other provinces or delivery to a collection point within the district. Two traders indicated that they delivered to a holding point on the border of Vietnam.

Trading partners and trading alliances

Clear trading preferences were expressed by the majority of traders. Almost all (58, 97%) would prefer to purchase directly from livestock producers, and a large proportion (45, 75%) would prefer to supply directly to slaughterhouses, rather than deal with markets or other intermediaries. There was also a high acceptance of trade between traders (40, 67%). However, only 11 (18%) expressed a desire to be involved in the international trade. Reasons given for this low rate were inexperience with international trade, and lack of a suitable international trading network through which to operate.

About half of the traders indicated that they had little or no awareness of trader associations in Cambodia.

If an association of traders were to be formed, the majority of those who had an opinion (19, 32%) felt that traders themselves should form this. Other organisations mentioned that could assist in the formation of a trader association included the Department of Animal Health and Production (14, 23%), or other government agencies (7, 12%). Formation of an association by a private company, a local authority, or a non-government organisation (NGO) were mentioned, but did not have strong support. Traders felt that an association had to be inclusive, allowing all members to be involved in decision-making, that procedures should be fair and transparent, and that it should be able to enlist support from the national government as well as NGOs.

Trader networks

Preliminary discussion with traders had previously indicated that there were informal networks of traders operating in Cambodia. All the traders indicated that this was the case, and that the effectiveness of the networks was based on positive relationships between players. However, the networks were considered to be fairly fluid, depending on the nature of each trader's operations. For example, part-time or short-term traders had more limited networks, whereas some

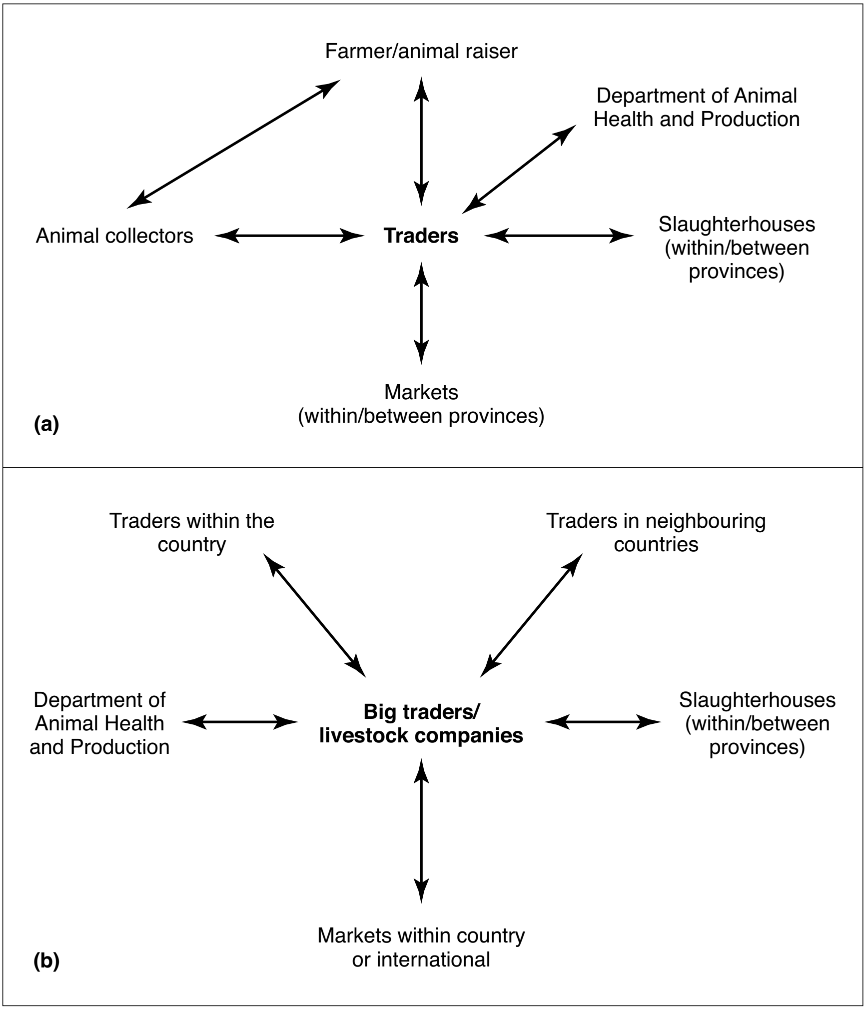

Figure 5. Network linkages that Cambodian traders recognise for (a) domestic and (b) international trading; arrows indicate flow of information

of the bigger traders had stable networks involving several provinces, slaughterhouses and international connections. Network maps were constructed from information provided by traders (Figures 5a and 5b).

Networks were maintained by a mixture of social and financial linkages. Informal communication was the main driver (78%), with more formal methods (telephone, in person information transfer) playing a lesser role. Financial drivers included payment (commission or retainer) to collectors who obtain livestock for traders, small traders who sell to the larger traders, and buyers from Vietnam sourcing stock in Cambodia. Specific linkages were developed with friends (83%), other traders (75%), family or relatives (45%), people within the same religious group (20%) and villagers (10%).

Price awareness

Traders perceived that the price of livestock was a complex issue, and identified some factors that influenced price. For cattle and buffaloes, price was strongly determined by the health and body condition of the animal itself. Demand within Cambodia was important, but internationally, only the price in

Vietnam was seen as important. Time of year was mentioned as being important, and this may be influenced by seasonal supply or festivals, as discussed previously. Of note was that the cost and availability of feed for holding cattle/buffaloes was not seen as an important issue; this was possibly related to the fact that most cattle and buffaloes are onsold quickly after purchase.

For pigs, the same issues of health, body condition and demand within the country were seen as important. Internationally, the demand from Vietnam and Thailand were identified as relevant. Festive seasons were also identified as important drivers of price, but unlike cattle and buffaloes, the availability and cost of feed and water were seen as important.

Why farmers sell stock

In an ideal system, sale of stock would result from planned production, which enables traders to optimise their activities on the basis of a regular production cycle. However, traders perceived that production is not necessarily predictable, and producers sell for a range of reasons other than planned production. Reasons given by traders for sale of stock are provided for cattle/buffaloes and pigs in Tables 4 and 5, respectively.

The perception of traders was that the need for funds was the main driver behind the sale of both cattle/buffaloes and pigs by producers: good prices were important to producers, but this took a secondary place to other pressing demands. The need for replacement or exchange stock was strongly identified as a major reason for selling cattle/buffaloes, but not as strongly for pigs. This may reflect an ongoing need for draught animals, a reason that would not apply to pigs. However, some replacement of boars and sows would be warranted, and this is reflected in trader responses.

Cost or availability of feed was rated highly by traders as a major reason for selling pigs, but was not for cattle/buffaloes, although it may be an important secondary reason for their sale.

Table 4. Reasons given by traders for why producers sell cattle or buffaloes (listed in order of major reason)

Reason given	Number of traders indicating the reason		
	Major reason	Minor reason	No effect
Urgent need for money	33	1	0
Good prices	25	9	0
Replacement/exchange stock	19	11	4
Disease status of animal	18	15	1
Age of animal	15	18	2
Surplus stock	12	22	0
Disease status in district	10	23	1
Body condition	8	21	5
Cost or availability of feed	5	19	10

Table 5. Reasons given by traders for why producers sell pigs (listed in order of major reason)

Reason given	Number of traders indicating the reason		
	Major reason	Minor reason	No effect
Urgent need for money	26	1	0
Good prices	18	9	0
Cost or availability of feed	18	7	2
Body condition	15	11	1
Disease status of animal	15	10	2
Age of animal	13	14	0
Disease status in district	12	13	2
Replacement/exchange stock	11	14	2
Surplus stock	6	21	0

Disease status was identified as a major reason for the sale of all stock by producers but only by less than one-third of the traders. Although not specifically indicated in the questionnaire, producers possibly sell stock they identify as diseased to minimise financial loss (i.e. sell for slaughter before the animal dies[1]).

Impact of sick animals

Anecdotal evidence suggests that traders actively seek out animals that are sick, particularly with FMD, and purchase them at greatly reduced prices. These stock are then either sold to slaughterhouses, which are not aware of their disease status, at close to full price, or kept in a holding yard for several days until symptoms of FMD have resolved. Traders were therefore asked about trading in sick animals, and to provide information about their knowledge of stock infected with either FMD or CSF.

About 83% of traders advised that farmers do sell sick livestock. The reasons they gave for farmers doing this included fear of the animal dying (67%), the opportunity to salvage some of the animal's value before death (48%), concern that the animal may not fully recover (23%), concern about the spread of disease (23%), the high cost of treatment (2%) and chronic weight loss (2%). Of those who commented that farmers did not sell sick animals, reasons given were that no-one will buy them, and that sick stock cannot be transported over long distances (5%).

Almost all traders (92%) stated that they were aware of and could recognise FMD because of common clinical signs. About half (53%) acknowledged that they sold stock with FMD. Reasons given were concern that the animals might not recover fully (22%), to make more profit (13%), concern that the animal might die (32%) and concern about losing money (23%). A variety of other reasons included that diseased cattle/buffaloes cannot be used for rice cultivation, concern about the spread of virus to other animals, the opportunity to salvage some value to put towards replacement stock, that disease is not contagious to people and the opportunity to sell stock for meat processing (dried meat). Some of these latter reasons for selling stock relate to animals that the trader may personally own or use in ancillary activities, and may be less related to trading per se.

[1] Subsequent discussion with village producers in Kampong Cham confirms this practice, which applies to FMD. Even though FMD is rarely fatal in adult cattle, villagers will often accept a low price when offered by a trader.

Although the majority of traders indicated that they would sell diseased stock to a slaughterhouse, some (7%) stated that they would onsell to other traders, and one trader mentioned selling diseased stock to other producers. Twenty-five percent (25%) of traders resold diseased stock immediately, and 12% waited for stock to recover before sale. Sale of diseased stock was primarily to slaughterhouses (33%), which were in the same district from which the stock were purchased (28%), in an adjacent district (3%) or another province (3%).

Where stock were retained until clinical signs resolved, these were kept at the trader's premises (their home) and may have been treated (5%), or in an isolation facility (8%). Just over half (58%) were aware that FMD was contagious. Understanding of the method of spread varied, with the following methods reported by traders: wind (17%), physical contact with sick animals (58%), via infected equipment or materials (13%), by transportation (15%) and by contacting the virus in the field (25%).

About half the traders (48%) indicated that the price of FMD-affected stock was lower than for healthy stock, but did not indicate the size of this difference. The majority (52%) indicated that once stock had recovered from FMD, prices returned to that of healthy stock.

Of particular note is that there appears to be ongoing trade in livestock infected with FMD, which could be expected to contribute to the persistence of the disease in an area or the spread between districts or provinces.

A similar approach was taken in regard to trader understanding of CSF. However, only eight traders (13%) knew of this disease and felt they could recognise it. The remainder of the traders were not aware of this disease. A reason for this may be that CSF is fairly acute, and pigs become debilitated, often dying.

Although five stated that they traded pigs with CSF, it would be unlikely that affected pigs were being traded in large numbers. However, this cannot be ruled out without further investigation; movement of preclinical infections and convalescent carriers are also possibilities. This requires further follow-up.

The majority of traders (67%) realised that spread of livestock diseases could result from transporting sick stock.

Disease reporting

Traders generally (35, 58%) recognised a need to report disease in livestock. Of those responding, the majority (24, 69%) would report to the village animal health worker. Others would notify the village or commune chief (10, 29%), a neighbour (10, 29%), a district or provincial veterinary officer (6, 17%), or report back to the original traders (4, 11%).

Regulations affecting trade

Although 78% of traders interviewed recognised that trade was regulated, those who did not (22%) comprised a substantial group.

Trade regulations apply to all trading activities. Traders were aware that trade regulations applied to trade between villages (47%), communes (37%) and provinces (71%), and internationally (57%).

Traders were asked if they had read the livestock movement regulations documents. Most did not have a copy (81%), and the remainder who did had not read the documentation. As a separate question, traders were asked whether they would like a copy of the regulations if available. Almost all (92%) indicated that they would. This latter response (i.e. 92% wanting a copy compared with 19% saying that they had a copy) suggests that any documentation previously accessed may have been only available to read in a district office, rather than to take away for future referral.

Compliance with regulations

Traders were asked to indicate whether livestock movement types were compliant with regulations. A varying number responded to each section of the question, but rarely more than about half of the survey group. Responses were asked for in increments of 10% (i.e. 10 options for each movement type). Responses tended to be spread across the range, and for simplicity are reported as the percentage of respondents indicating that more than 50% of movements in each category were compliant with regulations (Figure 6).

It should be noted that these results are what the traders themselves perceive as the situation. No attempt has been made to verify the accuracy of this.

There was some ambivalence towards the need for movement permits. Twenty seven (27, 45%) traders indicated one was needed, 7 (12%) were opposed to permits and 5 (8%) were neither opposed nor in favour; 21 (35%) did not respond to the question.

Approval to trade

Traders recognised the need to gain approval for trading activities. However, recognition of the source of that approval varied (Table 6)

This variety of approval sources may reflect the type of trading undertaken by traders—for example, those trading primarily between villages may seek commune authority to do so, rather than seeking authorisation from a higher tier of administration.

Thirty-four traders (57%) indicated that it was not possible to transport stock without proper paperwork,

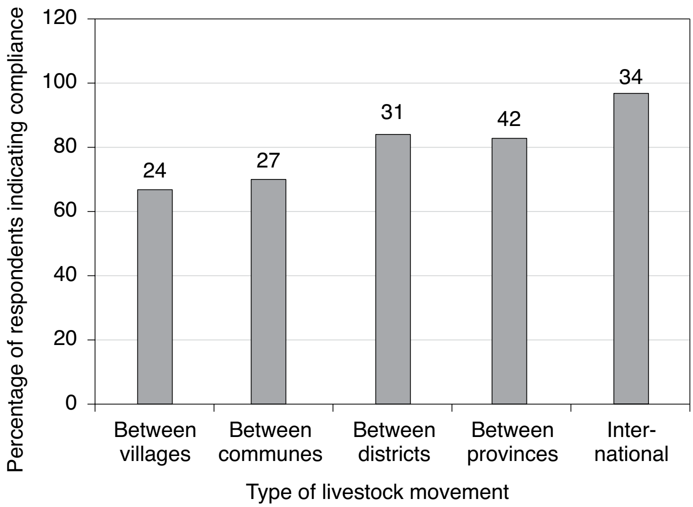

Figure 6. Percentage of respondents indicating that compliance with trading regulations was more than 50% for different types of livestock movement. Number above each column is the number of respondents answering for each movement type.

the remainder indicating that it was possible, or sometimes possible. Most traders (75%) indicated that there was a likelihood of being caught if they did not have proper paperwork. If traders were stopped without proper paperwork, they expected that there could be a warning (38%), a fine (75%) or nothing would occur (77%). Traders indicated that imprisonment was not going to occur (100%).

When a fine was paid, it was simply given to the person or group that stopped the truck—police or military police, or the officer manning an inspection checkpoint. The truck owner was considered responsible for paying the fines.

Costs of compliance

Producers indicated that the costs of compliance were varied. Table 7 lists the type of compliance cost, and the number of traders who listed it.

There was some reluctance to respond to this question, with 10 traders (17%) not willing to comment.

Traders commented that they expected to be stopped (by civil or military authorities) while transporting stock, and pay an unscheduled fee. This was considered a form of insurance against being subject to theft during transit, because the authorities patrolled the highways and kept them safe.

Profitability of a shipment or consignment was considered to be the same or greater if transport occurred without proper paperwork. In other words, it was cheaper to risk paying fees or fines along the way than to obtain official paperwork. This may be because the fees or fines totalled less than the cost of obtaining official transportation documents (48% of respondents), or because of the time consumed gaining official permission (28% of respondents).

When new regulatory information is made available by provincial or district veterinary staff, 27% of traders indicated that they sometimes attended updates.

Barriers to livestock trade

Traders were asked what were the main issues that they faced. Their responses are provided in Table 8.

Trader suggestions for overcoming or avoiding these issues are listed in Table 9.

Ongoing help—perceptions

Traders were asked if they would be prepared to continue assisting the project. All of them indicated that they would be willing to provide information on livestock trading and prices on a regular basis. This was conditional on contact being maintained by project personnel (i.e. traders were comfortable talking with project staff).

However, only half were prepared to share such information with a government agency and only one-third were prepared to share with a non-government organisation. Some traders indicated a willingness to share with other people, including district office staff

Table 6. Trader recognition of agencies granting trading approval

Agency granting trading approval	Number (%) of traders indicating the agency
Provincial Department of Agriculture	14 (23)
Provincial Veterinary Officer	15 (25)
Department of Animal Health and Production	4 (7)
Commune authority	10 (17)
Major trading company	12 (20)

Table 7. Costs associated with compliance with trading regulations

Types of compliance cost	Number (%) of traders indicating this cost
Stamp duty	5 (8)
Customs officers	2 (3)
Head tax	5 (8)
Trade certification	23 (38)
Police/military police en route	23 (38)
Company fees and charges	6 (10)

Table 8. Main problems experienced as traders

Trader concern	Number
Low interest by farmers in cattle raising	18
Market price fluctuation (price falls after purchase)	16
Difficulty in caring for stock during transport	15
Limited trading budget	14
Time-consuming to negotiate prices	13
Price pressure from large companies	13
Difficulty in finding new buyers	6
Difficulty with paperwork	5
Weight loss in transit/sickness	4
Competition from imported cattle	2

Table 9. Trader suggestions to address the main problems

Trader suggestions	Number
Transport stock through larger companies	12
Check stock more regularly in transit	11
Stop trading (temporarily) when prices are low	11
Cannot avoid selling when prices low	5
Reduce the tax on animals transported	3
Bigger trading budget	3
Careful price-watch	2
Arrange suitable funding ahead of time	2
Use stored feed during transport	2
Better government control on imported stock	1

or a district veterinary officer (6, 17%), a provincial veterinary officer (1, 2%) or a village chief (2, 3%).

The preferred method of contact was by phone (92%), but personal contact would be accepted by the majority (80%).

Discussion

The survey confirmed that there are two major groups of livestock traders: those whose activity is primarily within Cambodia (domestic traders who move stock from village to village, between districts or between provinces) and those who move cattle across national borders. The social characteristics of traders is similar between the provinces surveyed, and would appear typical of Cambodia's livestock traders.

International movements appear to be highly organised, with a limited number of large companies overseeing the trade. Contract work moving livestock for these larger traders is common. Much of the cattle trade originates in Thailand and terminates adjacent to the Vietnamese border, with a short transit time (15–24 hours, mostly at night) between loading and delivery.

There is some fluidity in trading activities of domestic traders. Many have their own properties or businesses, to which trading on occasion forms an additional income stream. Lower trading activity in the second half of the year makes this option attractive, and, in the case of small traders, an alternative enterprise is essential to maintain income.

There are different implications for disease spread resulting from each trader grouping. Some domestic Cambodian traders have acknowledged purchasing diseased livestock at reduced prices, before onselling them. This practice could reasonably be expected to result in the spread of disease between villages, districts and provinces.

Rapid transit of stock for international destinations can contribute to the spread of disease between countries, rather than within Cambodia, although spread to local cattle in Cambodia may result from mixing with local cattle before final delivery. Risks associated with rapid transit movements have been evaluated and reported elsewhere (Hawkins et al. 2012).

Networks of traders were identified, but these were loose, informal, and maintained by face-to-face encounters and phone conversations. No formal networks or trader associations were present.

Drivers of trade from the traders' perspective were market price (e.g. sales to traders by producers increased as prices rose, festivals within Cambodia created an increased demand for cattle particularly). An interesting product substitution was noted between pigs and fish in Cambodia, resulting in lower pig trading when fish were plentiful. Traders also commented that sale of stock for the domestic trade was also influenced by the supplier's need for funds (e.g. for ceremonial purposes such as weddings, or for debt repayment). Opportunistic sale of cattle when prices were high was reported.

Notably, price was not based on age, weight or body condition for cattle, but these characteristics were important in setting the price for pigs. Similarly, rises in the cost of feed for pigs would result in more pigs being available for sale.

Traders reported that livestock owners were more likely to sell sick animals, and more stock was available when diseases were prevalent in an area. Producers sold sick stock to get some return, in case the animals died. This also applied to FMD (which although not usually fatal, created a fear of fatality in producers' minds, leading to sale at discounted rates). Again, the implications of this practice for the spread of disease are apparent. Importantly, recent information (Charleston et al. 2011) reinforces the importance of early detection and management of FMD.

Cost of disease

The cost of disease is recognised by traders in relation to the cost of trading. Sick stock result in delays in delivery, and sometimes rejected shipments. Delays were costly because of the need to feed stock while being held pending later sale. However, some traders recognised an opportunistic benefit from some diseases. FMD is rarely fatal, and affected animals can be purchased at a discounted price. A small investment in feed and time results in the trader having a full-priced animal for onsale within 7–10 days. There is little recognition of the actual or potential affect that trans-boundary diseases in general have on international trade.

Although not specifically a disease, traders reported that they would value information on caring for stock during transport. Facilities are often very basic, and injuries during loading, transport and unloading are common.

Biosecurity practices and knowledge

Traders indicated that they generally had little knowledge or understanding of biosecurity practices relevant to trading. Mixing of stock in consignments, agisting stock in transit with their own animals, putting known sick animals with healthy ones, driving onto and off farms without truck washing, and carrying multiple consignments without truck wash-down were all standard practices.

Traders indicated that they would like more information on appropriate biosecurity practices for safe trading, without the message being complicated with biosecurity for other activities.

Biosecurity activities and infrastructure, such as disease notification to relevant authorities, quarantine facilities, health certification, inspection services, livestock market management and truck wash-down facilities were recognised by traders, but were not routine practice. Notification options were confusing, certification related only to the nature of the consignment, and inspection services related to shipment integrity and payment of appropriate fees and charges. Because of the confusion and cost of regulatory processes, compliance was considered by traders to be low for domestic trade, but somewhat better for international trade. The latter was attributed to the fact that large companies managed the international trade and ensured that all documentation was in place.

Other issues affecting traders

Traders perceived that producers had a low interest in cattle-raising as an enterprise, and used cattle primarily as a financial reserve to be realised when required. Consequences of this for domestic traders were that quality of stock and continuity of supply were substantial issues. Traders reported that they had to travel widely to make up a consignment. This in turn created an unacceptable level of price instability, making it harder to finance a shipment or trading venture. This was further compounded by personal financial constraints and the general difficulty in obtaining venture capital at reasonable interest rates.

Conclusions

Traders were a very congenial group to work with, willing to share their experiences and concerns with the investigators. They expressed a desire for ongoing collaboration, and requested input in the areas of disease recognition, safe trading (biosecurity) and transport management of stock.

Consequently, recommendations for traders include:

- development of culturally appropriate biosecurity messages
- regular disease updates, and information on disease management and disease prevention
- strategies for care of stock during transport
- ongoing liaison with traders for current awareness updates
- facilitation of an industry-run and operated livestock trader association to support and negotiate on behalf of traders.

In a wider context, recommendations from this survey to authorities with responsibility for disease control include:

- effective implementation of regional and national strategies for disease prevention
- fostering livestock production systems, for continuity of supply of quality stock
- revision and consistent application of movement permit systems
- introduction of biosecurity practices in livestock markets
- biosecurity facilities development, such as truck wash-down, at strategic locations
- implementation of effective quarantine and inspection services, offered at low cost to traders
- development of a clear disease-reporting mechanism, with a field service able to implement effective disease controls.

Continued liaison with traders (as they request) may be useful for reviewing and assessing changes or progress in management of trade and its implications for trans-boundary animal diseases.

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Working with traders to understand livestock movements and spread of animal diseases in Cambodia and Lao PDR

James Kerr, Socheat Sieng and Axelle Scoizec

This paper describes some outputs and insights from a project[1] designed to better understand livestock movements in Cambodia and Lao PDR to better assess and predict the risk of trans-boundary animal disease spread throughout the Greater Mekong Subregion (GMS). The project focused on movements of cattle, buffaloes and pigs and the associated occurrence of foot-and-mouth disease (FMD) and classical swine fever (CSF). Information collected from livestock traders was crucial in understanding movement drivers, trading practices that influence disease risk and the significant unofficial livestock trade across country borders. This information was collected by Socheat Sieng and the original study is published elsewhere in these proceedings (see Socheat Sieng et al. 2012).

An initial approach was to compile and analyse government permits to describe livestock movement patterns in Cambodia and Laos. Although these official records were useful in identifying and helping to quantify seasonal and longer term changes in movement patterns, they failed to capture important information about movement drivers, trading practices that influence disease risk and the significant unofficial livestock trade that accounts for the majority of cross-border livestock movements in the GMS.

Consequently, the project consulted extensively with livestock traders throughout Cambodia and Laos to determine:

- important trade routes for cattle, buffaloes and pigs
- quantitative movement data for those trade pathways
- sociological background information for livestock movements, including
  - trading practices
  - trader networks
  - trader knowledge of disease and biosecurity
  - movement drivers and trade impediments (official and unofficial).

Our research was also intended to develop a relationship with traders in these countries for ongoing consultation, research and education.

Method

A project consultant managed data collection from traders in each country. The Cambodian Department of Animal Health and Production (DAHP) and Lao PDR Department of Livestock and Fisheries (DLF) facilitated the process.

In Cambodia, a team of trained researchers used questionnaires to collect qualitative and quantitative data in one-on-one interviews with traders. The DAHP was excluded from these interviews to ensure confidentiality and encourage honest responses. Data collection in Laos followed a less structured checklist approach, with DLF staff present as translators.

Traders were interviewed throughout each country, with an increased focus on those provinces that featured significantly in long-distance and cross-border livestock trade. Data was collected in important border provinces in collaboration with the Food and Agriculture Organization of the United Nations, the Asian Development Bank and the World Organisation for Animal Health South-East Asia Foot-and-Mouth Disease Campaign (SEAFMD)

1 ACIAR project AH/2006/025: Understanding livestock movement and the risk of spread of trans-boundary animal diseases

study on cross-border movement and market chains of large ruminants and pigs in the Greater Mekong Subregion.[2]

'Snowball sampling' was undertaken when following trader networks, whereby interviews with key traders (primary respondents) identified suppliers and buyers in their trading networks for follow-up interviews (secondary respondents). This technique presented time, cost and logistical challenges when investigating trading networks that operate on a national and international scale.

Results

The major trade routes for cattle, buffaloes and pigs in Cambodia and Laos were described, particularly transnational pathways that represent the greatest risk of spreading trans-boundary animal diseases rapidly between countries (Figure 1). Trade volumes across these major routes between 2008 and 2009 were quantified (Figure 2).

Some of the more significant livestock trading and movement patterns in Cambodia and Laos during the study period are described below. Although these patterns may already be changing, the research also generated less ephemeral information about trader networks, trading practices and the trading environment (including geographical, seasonal, political and regulatory influences). This information will guide interventions aimed at reducing the disease risk associated with livestock trading.

Livestock movements in Cambodia

Cambodian cattle and buffaloes are directed to different slaughter markets according to body condition and quality. Vietnam appears to be the market for the best-quality animals, followed by Phnom Penh, with Cambodian provincial slaughterhouses the destination for animals of a lower standard. The poorest-quality animals, including the injured and diseased, are slaughtered locally.

Much of the movement of cattle and buffaloes from Cambodia into Vietnam is unofficial with some village-level trade in the vicinity of the border. Larger numbers of cattle and buffaloes move through export depots in an organised trading system facilitated by a small number of Cambodian trading companies. Livestock producers in Cambodia aiming to supply the Vietnamese market must be aware that the importation protocols may vary.

Cambodia also acts as a conduit for cattle and buffaloes moving from Thailand to Vietnam. During 2009, this transit trade involved the movement of 200–300 truckloads of cattle and buffaloes per month, representing up to 150,000 animals for the year. In mid 2010, this trade was100 truckloads per month, highlighting the variability of movement patterns. Further research is required to determine whether a proportion of these transit cattle originated in Burma, as this factor might influence the risk pathways for trans-boundary livestock diseases across the region.

Transit movements through Cambodia are rapid, with most animals taking less than 1 day to get from the Thai border to export depots located close to the Vietnamese border in the south-eastern Cambodian provinces of Kampot, Takeo, Svay Rieng and Kampong Cham (Figure 3). Once the transit livestock arrive in the Cambodian export depots, however, they may wait between several hours and several days before being walked into Vietnam. Contact between various livestock consignments in these depots may be a significant feature of the disease-risk pathways. Consequently, improved biosecurity practices or other interventions at these depots may represent an opportunity to significantly reduce (or at least assess) the disease risk associated with the livestock trade into Vietnam.

Cambodia is an importer of pigs, with Vietnam and Thailand the main suppliers. In recent years, however, Cambodia has imposed importation bans on pigs from Vietnam due to concerns about disease incursions. These import bans significantly altered movement patterns and pig population dynamics within Cambodia during 2008, with pig populations in some provinces greatly depleted in the attempt to meet market demand in Phnom Penh. Pigs are still imported from Thailand to meet the slaughter market demand in Phnom Penh and Siem Reap.

Livestock movements in Lao PDR

Laos is an importer and exporter of cattle and buffaloes, and a transit country for livestock destined for Vietnam and (more recently) China. Quotas of Thai cattle are imported through various provinces to satisfy the slaughter demand in Vientiane, which is also serviced by livestock from northern Lao provinces including Sayabuli, Luang Prabang and Xieng Khouang.

[2] This report can be found at the project website: http://ulm.animalhealthresearch.asia.

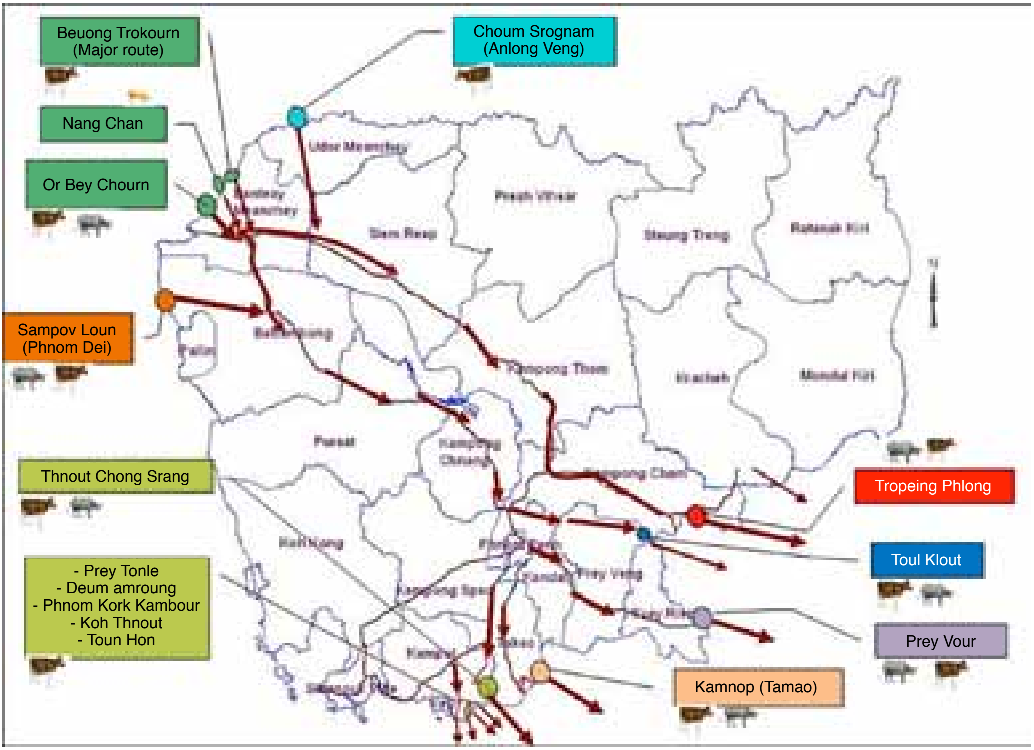

Figure 1. Transit routes for cattle and buffaloes moving from Thailand through Cambodia into Vietnam

The north-eastern province of Xieng Khouang is important as a production area for cattle and buffaloes and also as an export pathway for Lao and imported livestock moving into Vietnam. Most of the cattle and buffalo (and horse and goat) trade into Vietnam through Xieng Khouang is unofficial. This trade pathway was estimated to represent 2,500–3,000 head of cattle (60%) and buffaloes (40%) per month during 2008–09, of which 10% were thought to have originated in Thailand. Some of the livestock movement pathways that exit Laos through Xieng Khouang stretch from the southern, western and northern provinces of Laos, and feature a number of transaction and storage locations along their length. As with the Cambodian export depots, these locations represent both high-risk points for disease transmission and potential opportunities for applying risk-reduction strategies.

Significant transit movements of cattle were reported through southern Laos from Thailand into Vietnam, particularly the movement of up to 15,000 head of cattle per month through Savannakhet province during 2008–09 (see Figure 2). This particular movement reportedly had official approval from the Thai and Lao authorities, but required unofficial entry into Vietnam, highlighting the difficulty of understanding regional livestock movements by examining official records.

Early in 2010, increased rapid movement of cattle from Thailand through north-western Laos into China was reported as an increasing trend.

As with the transit cattle exported through Cambodia into Vietnam, further research is required to determine what proportion of the cattle and buffaloes entering Laos from Thailand originate in Burma.

Like Cambodia, Laos is a net importer of pigs. A limited number of fattened pigs are imported from Thailand for slaughter, but imports from Thailand mainly take the form of piglets for fattening on Lao farms. The locations of highest demand for pig meat in Laos are Vientiane, Luang Prabang in the north and Pakse in the south.

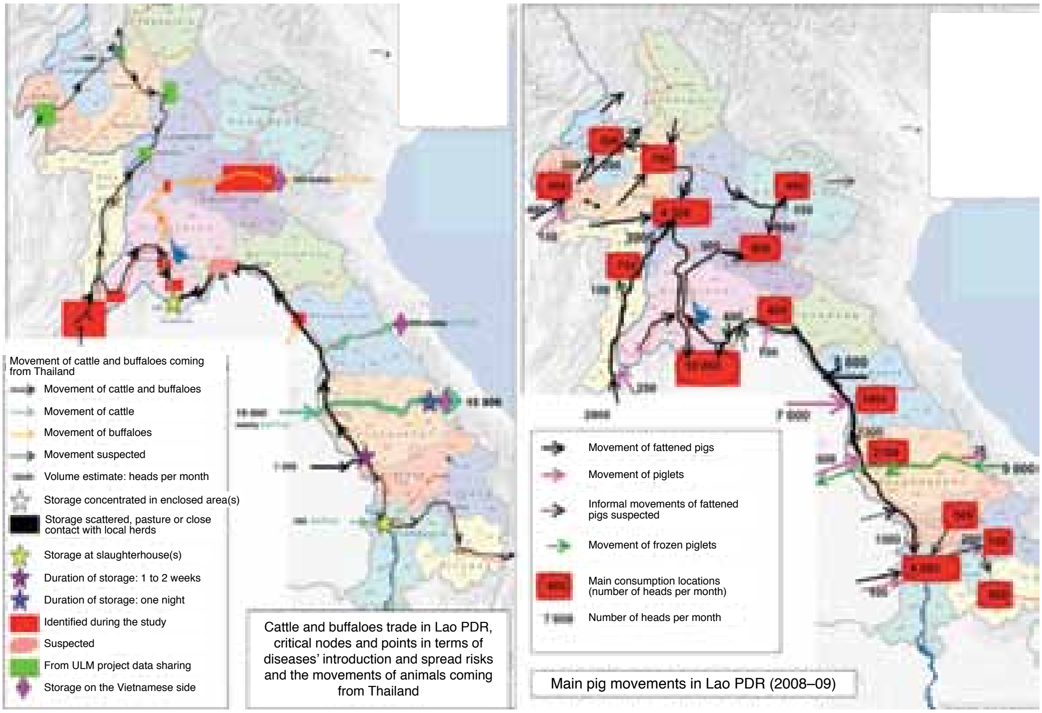

Figure 2. Trade routes and volumes through Lao PDR for cattle and buffaloes (left) and pigs (right), 2008–09

Market chains and trader networks

Market chains and trader networks were described in both countries (Figures 3 and 4). One-on-one interviews in Cambodia identified trading practices that carry a high risk of spreading disease. Of the Cambodian traders interviewed, 45% admitted to having traded in livestock affected with FMD, as the low prices accepted by farmers for sick animals can make them a profitable commodity for traders. Whether these sick animals are kept for recovery and resale or intended for local slaughter, they represent an important feature of the risk pathway for FMD, given the common trader practice of housing them after purchase with other livestock in the trader's village before resale or slaughter.

Fortunately, many livestock traders were keen to receive information about disease transmission and biosecurity, offering hope that trader education might be able to modify high-risk practices engaged in through ignorance.

Discussion and conclusions

Research with traders identified a number of critical points along the trade pathways where interventions might be attempted to reduce the risk of disease spread. These critical points included:

- physical features of the trade pathways, such as the small number of livestock depots located in south-eastern Cambodia, through which all transit cattle from Thailand must pass before entering Vietnam
- important stakeholders with the ability to influence the trade (risk) pathways, such as the small number of Cambodian trading companies that facilitate most livestock trade across Cambodia's borders
- trading practices used by livestock traders that carry a high risk of spreading livestock diseases.

This information will contribute significantly to risk pathway analysis for FMD and CSF in the GMS, which is intended to assist the development of animal movement policy in the region. A risk analysis of several major trade routes in Cambodia and Laos is planned in 2010–11, to identify future research

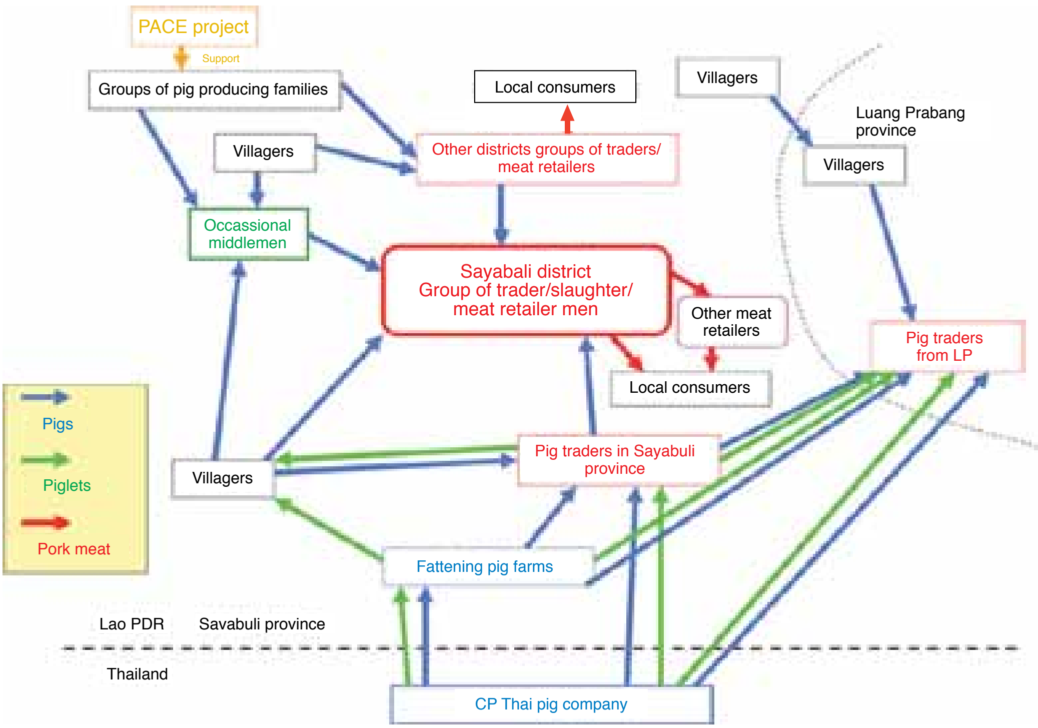

Figure 3. An example of a market chain for pigs, Sayabuli province, Lao PDR. The diagram cannot be fully explained because of a confidentiality agreement between the researchers and traders.

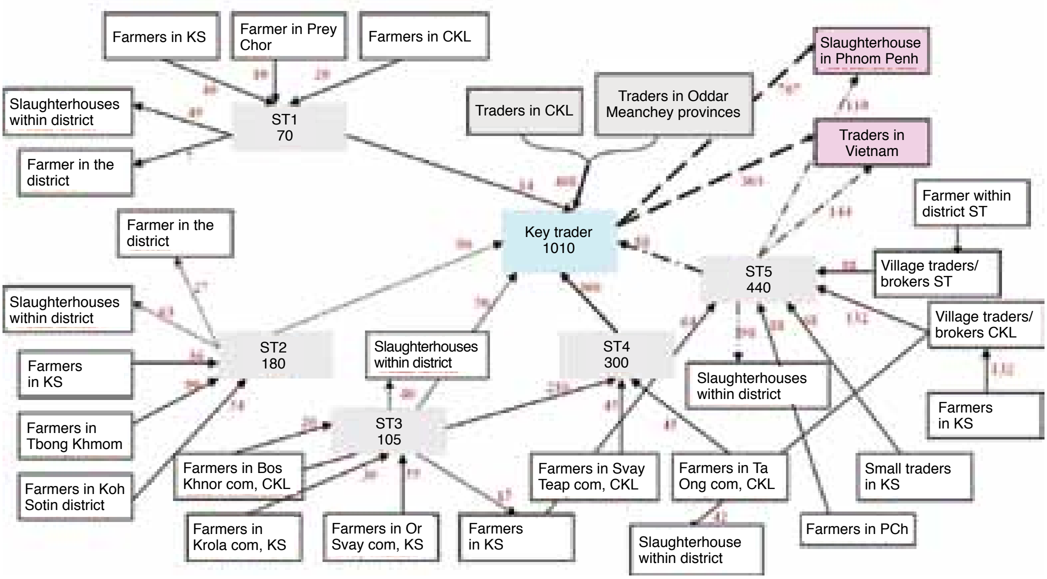

Figure 4. An example of a trader network in Kampong Cham province, Cambodia. The diagram cannot be fully explained because of a confidentiality agreement between the researchers and traders.

priorities. An initial risk analysis has been completed (Hawkins et al. 2012).

Opportunities have been identified for improved biosecurity practices and risk-reduction interventions at various points along the risk pathways for these diseases. Ongoing work with livestock traders is fundamental to these proposed interventions, and feedback meetings have already been conducted throughout both countries for that purpose.

The project is already developing and trialling educational materials in various formats to improve trader understanding of disease transmission and basic biosecurity.

The information collected by this project is not available from official sources. It has emphasised the importance of continuing to work with important industry stakeholders in developing animal movement and disease control strategies.

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Gathering information on livestock movement in Mekong countries

Ben Madin

Freedom from disease is a significant benefit to any livestock production system. Maintaining this freedom is a critical issue when considering any trade in livestock. Understanding the movement of livestock is vital for managing the risk of disease.

One of the intended outcomes of the research[1] reported here was to develop a model of the risk of foot-and-mouth disease (FMD) spread in the Greater Mekong Subregion. Such a model would help individual countries target their limited resources to best manage outbreaks and control disease while avoiding unnecessary trade restrictions. We needed to collect information on current disease outbreak locations, animal movements and the drivers of those movements, to provide suitable parameters for the model. A secondary but important consideration was to investigate methods of collecting the data in a sustainable manner to allow the model to be used after cessation of the project funding.

Information about animal movements can be used to define where disease came from, and where it went. It can also be used to predict likely animal movements and hence identify high-risk areas for new disease outbreaks. The current project was done with the classical understanding of FMD in South-East Asia being expressed in terms of three serotypes (O, Asia 1 and A), although new molecular research supports the presence of seven distinct pools of topotypes circulating in the region.

Several data-collection methods were tested for animal movements (based on official records) and livestock market prices (based on observations by provincial staff). Assessment of these data revealed that trade direction has changed significantly in the past 5 years. Some of these changes are due to policy, but economic growth is likely to be the main driver, reflecting the growing demand for animal protein in China and a relatively stable demand in Malaysia. The research also revealed that the system is highly responsive to change, and that to effectively handle changes in animal disease the management and the overall approach need to remain highly flexible, and be equally responsive. Numerous examples of traders walking livestock around checkpoints rather than paying the fees associated with using them were identified, confirming that inadequate resources exist to effectively control trade in the face of sufficient incentive to continue supplying livestock.

During this data-collection phase, the importance of setting priorities, identifying what outcome was to be achieved, what information was needed and how best to obtain it was critical. Determining whether we were trying to understand the network, the location of risks or the connections between industry sectors was important in identifying suitable data-collection points, and the appropriate analytical techniques.

Some of the critical areas for early discussion included the resolution of data analysis and hence data-collection activities: how much did we need (or could we afford) to spend to collect the data; and, as well as information on animal movements, what ancillary data did we require? The three aspects of resolution were as follows:

- Spatial resolution—will the project be trying to collect information at the village level, district level, country level, or somewhere in between?
- Temporal resolution—is the information required daily, weekly or annually?
- Animal resolution—are we really interested in tracking individual animals, or are we actually only interested in tracking movements of animal groups?

[1] ACIAR project AH/2006/025: Understanding livestock movement and the risk of spread of trans-boundary animal disease

The ancillary data included administrative boundaries (at an appropriate spatial resolution, but also in a format consistent between countries); topographic features such as roads rivers and mountains ranges, which were likely to impact on livestock movement; and population characteristics, including demographic density and occupation.

Issues and opportunities for the adoption of research

All the methods of data collection trialled during the project suffered some limitations—even the simplest (submission of paper records to head office) suffered due to the need for an already overworked central staff to subsequently enter the data. Network connectivity hampered provincial-level data entry and text message processing and ongoing office visits are too expensive for the development of a sustainable system. Data collected for other purposes are often insufficient for a specific project, and 'base' data (roadmaps, infrastructure locations etc.) are not readily available.

Seven options for tracking animal movements were identified and evaluated, and are shown in Figure 1. Based on the above priorities, highly sophisticated technical solutions may provide a high level of understanding, but have a high resource cost. For example, satellite tracking of individual animals, which can provide almost continuous location information, is not only highly expensive, but requires the fitting of expensive radio transmitters, which would provide a significant deterrent to a potential purchaser.

As new technology becomes available it is possible that cheaper and more effective electronic devices could be deployed for research purposes, for example, based on mobile phone (GSM) transmitters. In the meantime, more conventional systems such as individual animal identification (using visual tags or electronic radio-frequency devices) are cheap to deploy per animal but require substantial capital investment in equipment to capture and store information on animal location.

This project investigated and primarily used existing records of animal movements. Capturing this data on a regular basis was difficult. Different offices were more-or-less likely to contribute depending upon a range of parameters, including general interest in the project, perceived benefit to the office, the amount of other work that had to be done or concerns about information sharing. Much of this data had already been captured (i.e. on paper forms), lending support to the hypothesis that smarter data-collection solutions are likely to overcome many of these problems.

Other opportunities identified during the course of the project included capturing data provided on a monthly basis from provincial reports and using that to verify individual reports. Alternatively, with some small changes, the need to submit multiple reports could be reduced.

Implications for future research and development

Over the course of the project, a great deal of useful information was gathered and a number of weaknesses in current understanding and practices were identified:

- The pathways of underlying animal movements cannot be assumed to be fixed.
- The data available through official pathways on animal movements are likely to be an underestimate—even where records are available they may not contain sufficient information on animal movements.
- Data collection can be done on a national or regional level, but substantial ongoing effort is required to ensure high-quality data are collected.
- There is substantial duplication and redundancy in the current arrangements for recording information on animal movements.

More efficient and effective data collection is likely to be possible in the future with the wider reach of mobile telephone networks, their associated data capacity, and improvements in technology such as netbooks, smart phones and other electronic recording devices making devices more affordable even for smaller projects to deploy in large numbers. Examples such as a disease-recording project in southern Africa using digital pens to send out messages through mobile phone modems provide an insight into the potential to merge technological solutions with existing paper-based requirements.

There are a number of reasons to track movements and, for the purpose of this project, improving biosecurity and food security through controlling disease outbreaks was the primary goal. However, increasing concerns about animal vaccination status and food safety in the region increase the importance of being able to authenticate certification. While there is general agreement that vaccination will be an essential component of animal disease control

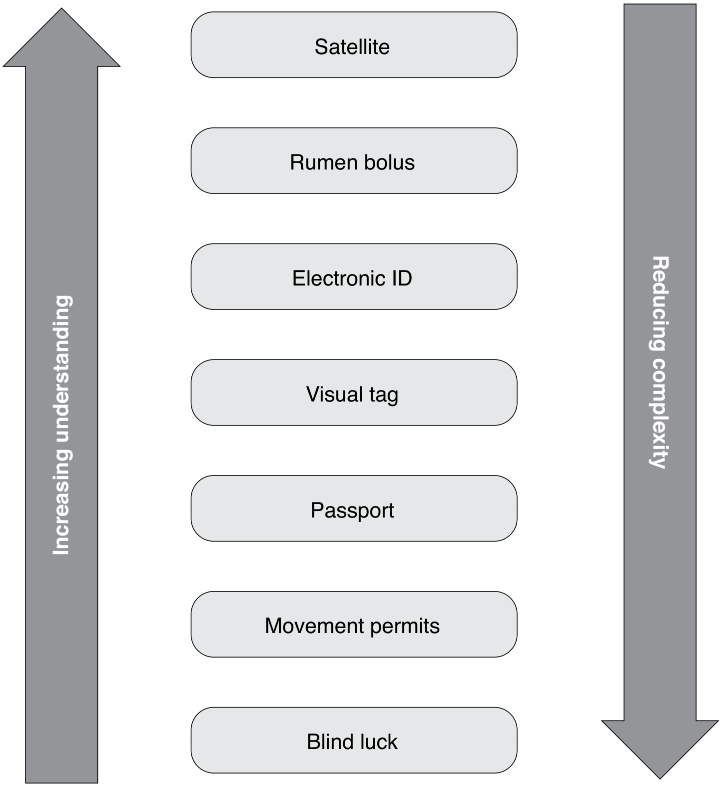

Figure 1. Some options for animal tracking

programs (including but not limited to the FMD control program), adding value to this vaccination is essential to ensure the buyer can not only see the benefit of purchasing vaccinated animals but also be confident that the animal they are purchasing is indeed vaccinated. Under current arrangements, an animal's nationality can be changed rapidly and easily, normally by simply removing its country tag. Certification will probably become the biggest hurdle for animal movement management in the next 20 years, yet there is no commonly agreed framework for best practice in animal identification, disease certification, or understanding of buyers of the need for certification or its benefits. For the system to succeed, there will be a requirement for unique animal identification on a region-wide basis, regulatory support and the ability to implement and maintain a viable, cost-effective solution.

Currently, there is no significant demand for a whole-of-life animal identification system in the Mekong countries. This may change as food safety becomes a more significant issue in the eye of regional consumers; however, identification systems for a disease-specific control program—which may be limited to temporary identification measures—still requires regulatory controls whether it uses tail tags, paint brands or hoof brands. Further research will be required to support decision-makers to choose the most appropriate solution for the long term.

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Biosecurity systems and capacity

Free-ranging animals can be a source of new disease epidemics of foot-and-mouth disease and classical swine fever. (Photo: Sieng Socheat)

Linking development and research projects: the Northern Regional Sustainable Livelihoods through Livestock Development Project

Syseng Khounsy

Livestock are important for smallholder livelihoods across Lao PDR, especially in the northern and upland provinces where arable land is limited. Reducing reliance on shifting cultivation by increasing the contribution of livestock to poverty reduction has been a national priority for several decades. However, this requires a better understanding of how to manage the health and production constraints affecting smallholder livestock production. In 2007, after two decades of research and pilot development projects by national and international partners, and with financial support from external donors,[1] the government of Laos initiated a major livestock development project in five provinces in northern Laos. Known in brief as the Livestock Development Project (LDP), the project aimed to scale out best-practice approaches for poultry, pig, cattle and buffalo production. The LDP has ongoing connections to 'research for development' projects in Laos. The purpose of this paper is to describe those connections and discuss how both the research effort and the development initiatives can be of mutual benefit. This paper addresses the questions: 'How can the co-location and collaboration of small research projects with the LDP, plus the inclusion of research and extension training programs, assist the LDP to have positive impacts in the project targeted villages?' and 'How can research be better targeted by association with the LDP?'

There are many differences between the LDP and both research and pilot development projects, particularly in the scale of effort and resources required to achieving significant impact. The LDP is being implemented in the five northern provinces of Bokeo, Luang Namtha, Luang Prabang, Huaphanh and Xieng Khouang, in approximately 1,500 villages in 18 priority poor districts. Of these, the project directly targets villages with the highest levels of poverty but where at least 50% of the households can rear livestock (approximately 408 villages). Of the 24,000 households in these villages, the LDP is likely to directly affect 17,000. In contrast, most research projects only have capacity to work in 5–20 villages in one or two provinces.

The immediate issue raised by the huge increase in scale of the LDP is the need for increased capacity of provincial and district staff to work effectively with smallholders to implement and adapt those technologies that have been developed and successfully tested in smaller research projects. Methods for training local staff were developed in earlier projects, notably the Forages for Livestock Project (FLSP).[2] The FLSP was designed to improve livelihoods in the northern uplands of Laos by improving the productivity of small and large animal systems,

1 Donor support is primarily from loans by the Asian Development Bank and the International Fund for Agricultural Development (IFAD), with grant support from the Swiss Agency for Development and Cooperation (SDC), the Asian Development Fund (ADF) and the Japanese Fund for Poverty Reduction (JFPR).

2 The FLSP was implemented by the International Center for Tropical Agriculture (CIAT) and the National Agriculture and Forestry Research Institute with donor support from the Australian Agency for International Development (AusAID).

increasing labour efficiency and reducing workloads in livestock production.

By 2005, the project was working with more than 1,300 farmers in more than 100 villages in each of four northern districts. The FLSP was seen as a 'proof-of-delivery' project that could deliver promising research results, resulting in significant livelihood impacts on a moderately large scale.

Two of the key lessons from the FLSP relevant to capacity building, were that:

- few of the impact-yielding systems can be 'photocopied' from one place to another—new farmers will always need to adapt the systems to their own realities
- there are simple ways of helping district staff develop a vision for how extension processes can work and then acquire the technical skills and extension tools that allow them to put this vision into practice within the context of smallholder livestock systems.

The insights and new techniques developed by the FLSP were further improved by more detailed research on capacity-building methodologies by the Extension Approaches to Specific Livestock project (EASLP).[3] The EASLP refined the extension approaches and evaluated the effectiveness of a range of capacity-building methods being used by livestock extension staff. The established techniques evaluated included cross-visits, farmer forums and delivery of village learning activities. A new technique developed jointly with the LDP was use the use of 'digital stories': simple CD-based presentations in the many local languages of the northern provinces that can be used in every village. Many of the digital stories are based on household case studies. The project concluded that the design and use of a combination of methods or approaches achieves the best outcome, which is consistent with our understanding of adult education and consideration of the importance of catering for different learning styles. An example of an effective capacity-building program would be to encourage district staff to work directly with farmers after the workshops provided at project implementation, followed every 6 months by training in a specific topic according to staff and farmer needs. Regular mentoring and staff meetings are also important initially, with at least one cross-visit or study tour. Other factors contributing to effective capacity building are to select enthusiatic staff, encourage teamwork, provide motivation through rewards for all staff, provide opportunities for staff to work with non-government organisation personnel, ensure regular opportunities to share skills and exchange ideas, and promote the link between theory and practice (i.e. enable school and college learning to be applied by in-the-field learning opportunities).

Additional substantial investment[4] in capacity building was then made to ensure there was the minimum number of capable district staff to start implementing the LDP, and to capture the field experience from the earlier work. Guidelines for project management, staff capacity building and best-practice technical options were developed.

Two additional research projects have been significant to the planning and implementation of the LDP, both of which focus on large ruminants as improving cattle and buffalo production is seen as offering substantial opportunities for income generation using proven technologies. The project 'Best-practice health and husbandry in cattle and buffalo'[5] (Windsor et al. 2012) aims to refine technologies and recommend practices as well as measure the success of delivery of these interventions. The intensive staff training required in this project enabled a much broader and more detailed training program for 26 LDP staff. The program included modules in animal health, biosecurity, nutrition, reproduction and marketing. The second project explored the risks that emerged from increased trading in cattle and buffalo trade within Laos and with Vietnam, China and Thailand. The project engaged with trader networks in the research project 'Understanding livestock movements and the risk of spread of trans-boundary animal diseases'[6] (Kerr et al. 2012).

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3 The EASLP was implemented as a partnership between the Lao PDR National Agricultural and Forestry Extension Service and Charles Sturt University with support from ACIAR.

4 TA 4406: Capacity building for smallholder livestock systems – LAO PDR, financed by the Poverty Reduction Cooperation Fund of the Asia Development Bank, and implemented by the Lao PDR Department of Livestock and Fisheries (DLF) and CIAT.

5 The best-practice project is being implemented as a partnership between the DLF and the University of Sydney with support from ACIAR and additional funding for training from the Crawford Fund.

6 The understanding livestock movement project is a partnership between the DLF and the Department of Agriculture of Western Australia with support from ACIAR.

Conclusion

Substantial investments in several research projects have identified promising findings and have progressed these through evaluation, pilot testing and scaling out. These projects aim to build the capacity of the technical and extension staff responsible for scaling out the most suitable interventions, delivering knowledge and technologies that can move the smallholder livestock subsistence system to a productivity focus capable of improving farmer incomes.

Building the capacity of extension staff in the LDP is a critical process that has benefitted directly from co-location and collaboration of ongoing research projects with the LDP. In particular, the inclusion of a research and extension training program has enabled the introduction of new knowledge and learning processes on the large scale required for a major development project. The larger cohort of trainees from the LDP benefitted from the training workshops as there was a wide exchange of ideas and field experience by attendees from different backgrounds. The LDP staff provided the research projects with larger sampling areas and more opportunities to learn about the development needs of the region. Importantly, project research outputs can be applied more rapidly and more effectively across a wider area for the benefit of substantially more smallholders farmers.

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Livestock trading and foot-and-mouth disease risk

Chris Hawkins, Socheat Sieng and James Kerr

While the movement of people, equipment and animal products such as meat and milk pose a real risk of transferring foot-and-mouth disease (FMD), movement of live animals poses probably the greatest risk. In the greater Mekong area, cattle move over large distances in short periods, with few stops or health checks between departure and destination. Further, checking to see if an animal has FMD will only detect those with active or recent infection. It will not detect those incubating the disease, nor will it detect those carrying the virus post-infection. As part of an ACIAR project,[1] we have interviewed traders and observed them trading livestock across borders. Information collected in this study has been used to examine the impacts of prevalence, inspection effectiveness and potential for infection in transit on moving FMD across international borders.

Trading pattern

Cambodian traders intent on selling into the Vietnamese market will often source stock from Thailand markets near the Cambodian border. These stock are inspected and, if considered satisfactory by the trader, incorporated into a shipment or consignment of about 50 animals. Transport is by truck, and vehicles travel more-or-less diagonally across Cambodia, terminating near the Vietnamese border. Two main routes may be taken (Kerr et al. 2012). The journey usually takes less than 24 hours, and any inspections along the way are for shipment integrity purposes—that is, to ensure that the number and type of stock on the truck corresponds to that listed on the transport permit. On arrival near the Vietnamese border, stock are unloaded and placed in a holding facility. These facilities may allow contact between different shipments. At this point, Vietnamese buyers may inspect the consignment and could reject any animals showing signs of disease or the whole consignment. Stock are then walked across the Cambodian–Vietnamese border, before completing their onward journey by truck to an abattoir, or occasionally a feedlot. About 700 such journeys occur each year. During the walk across the border, cattle may come in contact with domestic cattle tethered nearby.

Assessing the risk

A scenario tree was constructed using Microsoft Excel®, and a risk or probability assigned to each branch of the tree. Each probability was entered as a range of possibilities, assigned empirically from best-guess information, using @Risk (©Palisade Corporation, New York). This software enables an evaluation of the importance of each component of the scenario tree and, in this case, indicates where the 'weak links' are and where more information is needed. The same data in the scenario tree were used to construct a discrete quantitative model to predict the number of infected shipments likely to enter Vietnam, as a cross-check to assist in the validation of model outcomes.

Results

The scenario tree itemises the conceptual events in the transport of stock from Thailand to Vietnam in a stepwise manner. This is outlined in Figures 1 and 2. Each step is assigned a likelihood value, obtained primarily from discussion with traders, with inputs from provincial and district offices, and Department of Animal Health and Production staff. These

[1] AH/2006/025: Understanding livestock movement and the risk of spread of trans-boundary animal diseases

likelihood values are expert opinion and best guesses. They are not researched or confirmed by reference to collated data. Such data, though highly desirable, is not available. The scenario tree takes into account the possible prevalence at the market in Thailand, the ability of traders to remove animals that may be affected with FMD, and the chances of reinfection during stopovers or when walking across the border into Vietnam.

Simulation using the model

The likelihood of an infected shipment entering Vietnam was calculated using @Risk as described above. The model was recalculated 1,000 times, and yielded the following data (Table 1).

The model indicates that with the given estimates, the chance of a shipment arriving in Vietnam with infected cattle is about 6 in 1,000 by this trade route. Since there are about 60 shipments a month, or about 700 a year, then 4 could be infected. This value is an average that lies somewhere between about 3 in 2,000, and 2 in 100. The very wide spread around the average indicates that there is a need to further research this data. Information is being sought on FMD in Vietnam associated with this trade route.

One of the very valuable outcomes of this approach to risk is that we can gain an indication of the important components of each of the output calculations along the way, sometimes referred to as sensitivity analysis.

The first output of interest is the likelihood that infected cattle will make their way to the final destination in Cambodia, a holding facility just before the border with Vietnam. The tornado diagram (Figure 3) indicates that the biggest contributors to this are the prevalence in the cattle when purchased initially, and the ability of traders to exclude animals affected with FMD.

Secondly, it is helpful to know the key determinants for an infected shipment entering Vietnam. This is given in Figure 4; the analysis shows that the two key factors are the likelihood of a shipment becoming infected in the holding facility (secondary prevalence), and the ability to exclude infected stock at this stage. Cattle could become infected in a number of ways during their time in the holding facility: by using an area recently vacated by an infected consignment, by mixing an uninfected consignment with an infected one, or by contact between pens at feed or water points. Each of these possibilities is included in the model. Earlier factors, the original prevalence and capacity to remove infected animals prior to the holding facility, although still present, play an insignificant role at this stage of the transport chain.

Discrete quantitative modelling approach

A discrete quantitative shipment model was constructed using information from traders; they indicated that there were about 50 animals in a shipment, with about 50–60 shipments each month, contributing to about 36,000 cattle moving into Vietnam annually by this trade route. While there is some seasonality to livestock movements, this was not modelled due to lack of detailed information. Such variations may influence the timing of infected cattle moving, but in a model of this nature would not affect the final numbers in the outcomes. Onto this movement information, the probabilities used in the scenario tree were applied to determine the number of infected animals entering Vietnam. Being a discrete model, only whole shipments and whole numbers of animals were 'allowed' to move. This influences the output, and adds a level of realism that the scenario-tree approach lacks.

The model was run for 1,000 iterations, each iteration representing a month of trading. Outcomes were much as expected: there were 46–59 shipments per month, resulting in 2,303–3,461 cattle shipped monthly, and the number of infected animals was 0–4 per month, with averages of less than 1 per month and about 8 per year. This is a little higher than the scenario-tree approach, and reflects the nature of the model, which only deals with whole animals, rather than probabilities, as described earlier.

What do not seem to make a big difference to the risk outcomes are inspections in transit, and the possibility of becoming infected by contacting local cattle while walking across the border from

Table 1. Simulation output of the likelihood of an infected shipment arriving in Vietnam

Number per thousand shipments						
Minimum	Mean	Maximum	5%	95%	Iterations	Variance
5.68E-04	5.65E-03	1.78E-02	1.55E-03	1.17E-02	1,000	9.87E-06

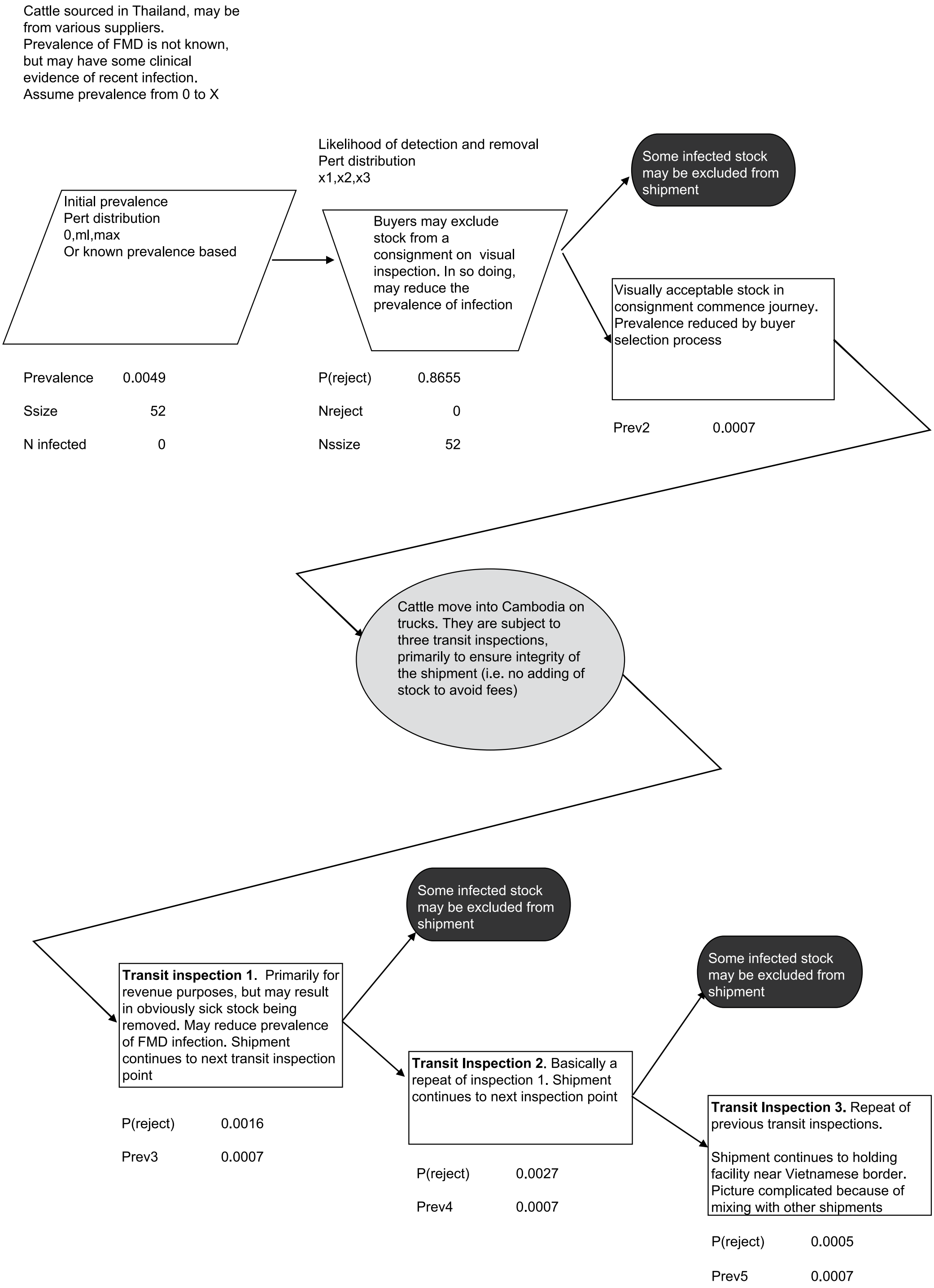

Figure 1. Scenario tree for the transport of stock from Thailand to Vietnam—Thailand to final transit inspection

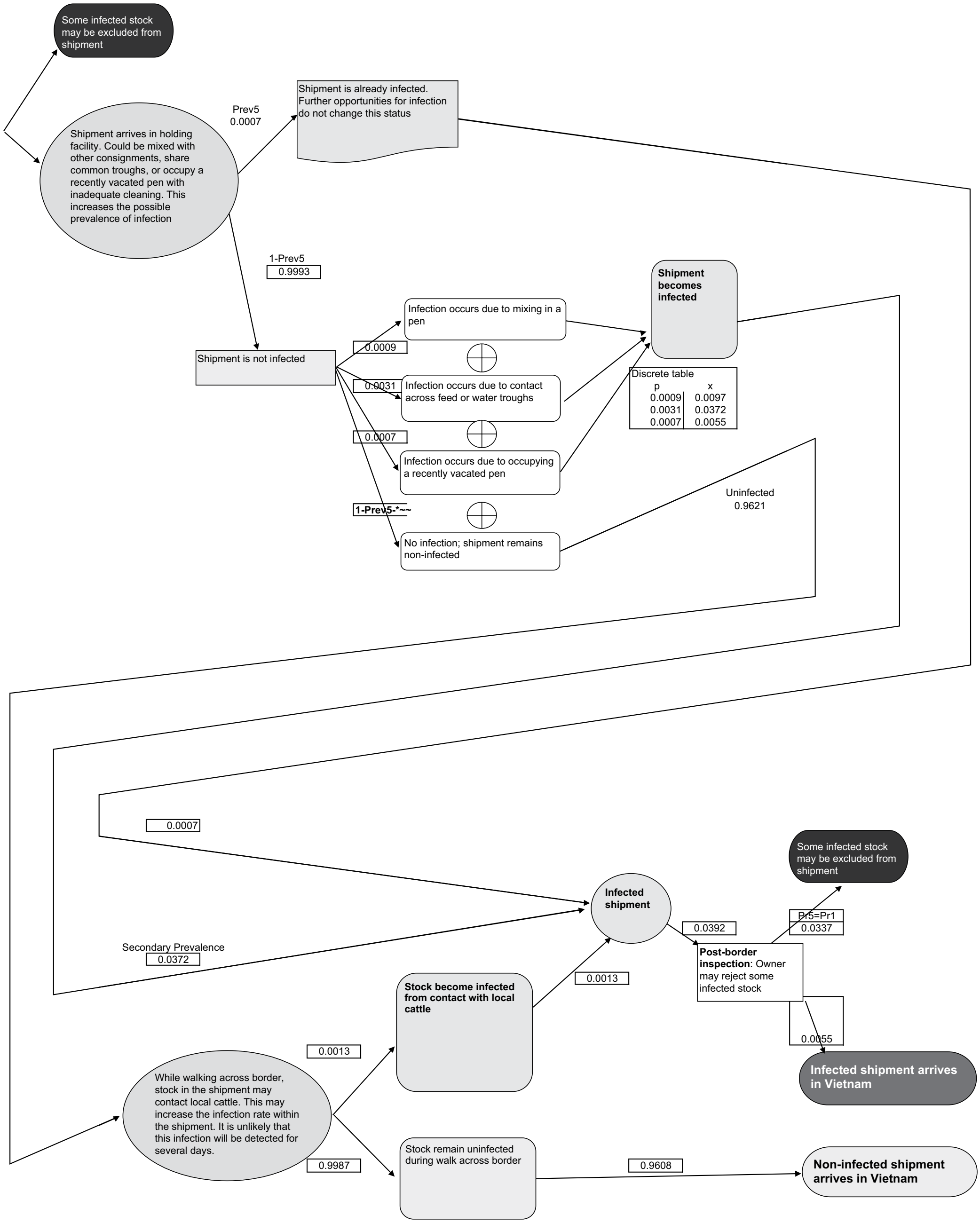

Figure 2. Scenario tree for the transport of stock from Thailand to Vietnam—final transit inspection to arrival in Vietnam

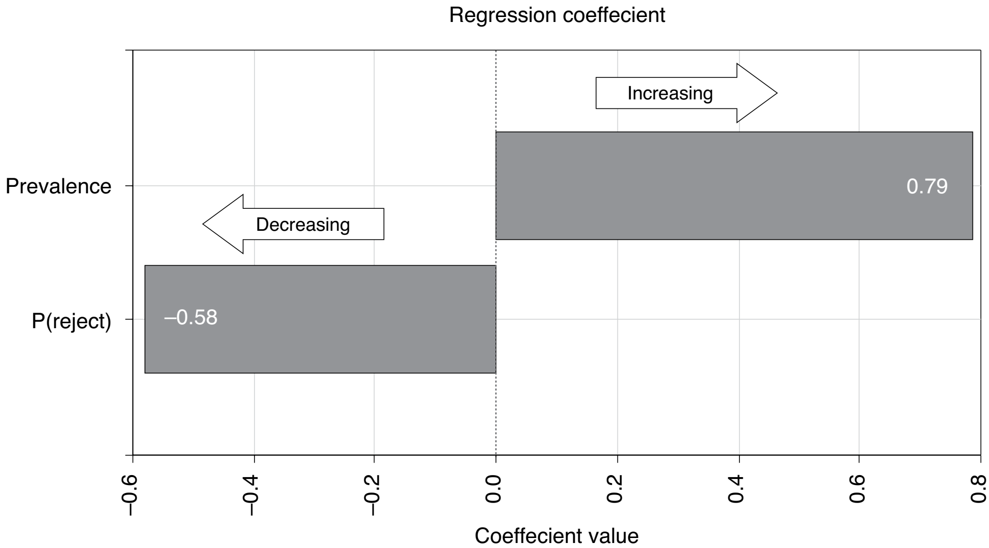

Figure 3. Tornado diagram indicating main contributors to the prevalence of foot-and-mouth disease after the last in-country inspection and when the shipment enters the holding facility near the Vietnamese border. 'Prevalence' is the disease frequency at the point of purchase; P(reject) is the likelihood that infected cattle will be rejected.

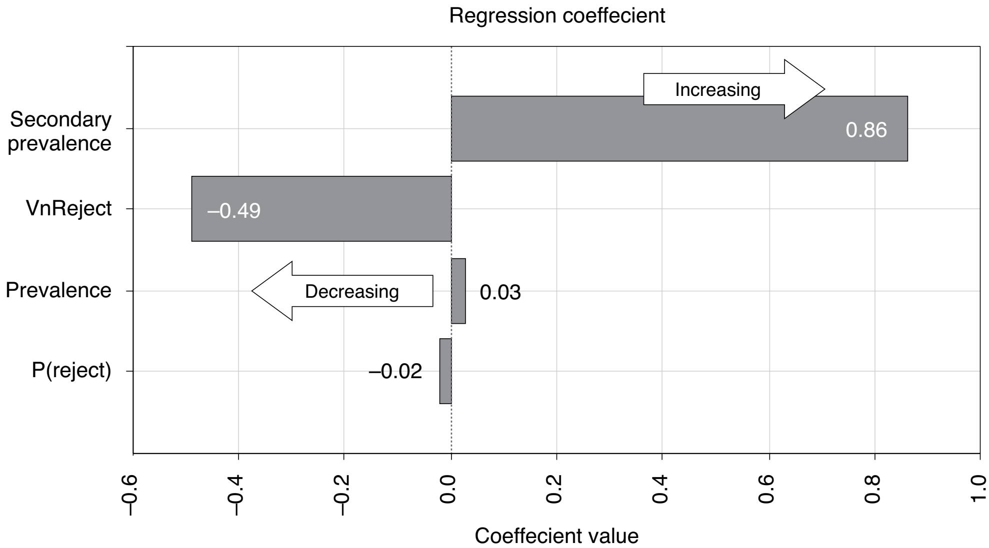

Figure 4. Tornado diagram of key factors determining whether an infected shipment enters Vietnam. Secondary prevalence is the likelihood of infection during a stopover in a holding facility, and VnReject is the likelihood of being rejected by Vietnamese traders.

Cambodia into Vietnam. This is probably because transit inspections are intended to count the animals to ensure that the number on the truck corresponds to that on the trade movement permit (i.e. no biosecurity activities are undertaken) and that shipments tend to travel at night when visual appraisal of the stock is difficult. Walking stock across the border allows for very minimal contact with stock that may be tethered on the roadside, and any sick stock are more likely to be retained in the village for extra care rather than be walked to the roadside for feeding.

Understanding and interpreting the models

It is always wise to remember that a model is only a representation of the world, not the real world. However, such models do give a level of clarity that may not otherwise be apparent, and may identify areas where information is lacking.

Overall, the models indicate a number of areas where further investigation is needed:

- Prevalence at the source of cattle—it is important to know whether cattle are infected in the markets from where they are purchased by the traders.
- Ability of traders to exclude infected animals—how effectively can buyers identify and remove animals carrying FMD?
- Potential for new infections before reaching the destination—how likely is it that cattle will become infected in holding facilities near the border to Vietnam?
- Ability of the trader from Vietnam to exclude infected animals—how well can a trader from Vietnam recognise and remove infected stock from a shipment?

Addressing these issues first and foremost requires a genuine commitment to surveillance for FMD, and an effective strategy to keep infected animals out of markets. This is probably the biggest challenge facing an export livestock industry seeking to minimise the threat of FMD.

Secondly, the ability to identify and remove animals infected (or carrying) FMD is problematic. Stock showing signs of active disease would be relatively easy to exclude, as would those with suggestive lesions, or lesions that are healing after active infection. Visual appraisal is unlikely to detect convalescent carriers, or cattle incubating FMD. The transit time for livestock from Thailand to Vietnam is approximately 24 hours, which is sufficient for the virus to spread, but may not always be sufficient for clinical disease to become apparent. A rapid test to determine whether stock are infected (a cow-side test) is needed to ensure that all stock are free from the FMD virus.

Thirdly, the potential to spread between consignments in holding facilities requires very high-level biosecurity practices—the ability to keep shipments strictly separate, so that there is no physical contact, movement of aerosols or other body products between shipments. Staff engaged to feed, water and tend to stock in holding facilities would need to maintain strict biosecurity standards.

Clearly, some of these strategies are not practical at present, and some alternative methods would need to be considered. In the short term, the following could be worthwhile:

- Ensure every animal coming into the market has been effectively vaccinated with the most commonly occurring strains of FMD, at a time before market that enables protective antibodies to develop. This would markedly reduce the effective prevalence of infection in trading cattle at markets. However, it would still be wise for traders to inspect stock carefully, and exclude any that show active or recent signs of infection with FMD.
- Make better use of the official checkpoints along the journey—increase the benefits of stopping to examine livestock on trucks. Any signs of FMD in the stock should warrant biosecurity action. Confirming or excluding FMD in the shipment will have long-term benefits to transporters and buyers.
- Minimise time in holding facilities, and implement a management system for these facilities that includes thorough cleaning of holding areas between shipments; construction of an isolation area for suspect consignments, away from the main holding area; development of a rapid communications process that alerts traders to the presence of FMD when or if it occurs; and application of total quarantine of a holding facility if FMD is detected.
- For traders in Vietnam buying stock, ensure a minimum time from purchase to slaughter. In other words, as soon as an animal is purchased, consign it to the abattoir. If stock are to be kept for any length of time (e.g. in a feedlot), arrange these as a special consignment, ensure they were vaccinated ahead of time, and keep them isolated from other stock from the time of vaccination.
- Routinely clean trucks carrying livestock after every shipment. There is no way round this—trucks become contaminated, and can be very efficient spreaders of FMD.

- Promote the importance of these strategies through effective media and educational campaigns.

Again, these suggestions may sound impractical. However, we are dealing with a highly infectious disease that nobody anywhere in the world wants. Only with long-term commitment from all stakeholders (traders, buyers, cattle growers, governments, non-government organisations and private companies) can advances in FMD control be achieved.

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World Organisation for Animal Health performance of veterinary services

Ronello Abila and John Stratton

South-East Asia has been at the centre of emerging infectious diseases (EIDs) over the past decade. The emergence of severe acute respiratory syndrome (SARS), followed by highly pathogenic avian influenza H5N1 and, last year, pandemic influenza A (H1N1/2009) has mobilised governments, and international and multilateral organisations to come together to develop common strategies to combat the threat of EIDs. Stronger veterinary services, backed by good governance and high-quality legislation, are at the core of the capability to implement strategies to engage effectively in this fight.

Several interrelated factors contribute to the emergence, spread and persistence of infectious diseases. Globalisation, including explosive growth in international air travel and international trade of animals and animal products, increases the spread of EIDs. The emergence of an EID in one country can rapidly have a devastating effect globally, never more clearly illustrated than by the emergence and global spread of SARS. Ecological factors such as rapid urbanisation and habitat destruction have brought humans, domestic animals and wildlife in closer association, with associated risks of disease emergence. Rapid livestock intensification has sped up disease (particularly viral) transmission, circulation and recombination among heavy concentrations of host animals. Climate change may also contribute to disease emergence and spread, particularly relating to host ranges for vector-borne diseases through changes in temperature and rainfall. Veterinary services need to adapt and modernise to address these continually evolving EID risks.

Veterinary services also play a vital role in other areas such as agricultural and rural development, food security, poverty alleviation, food safety, market access and safe trade. With a rapidly growing global population, strong economic growth and a burgeoning middle class—particularly in Asia—demand for animal protein (meat, milk and eggs) is growing rapidly, with some projections indicating a 50% increase by 2020, especially in developing countries. Veterinary services are vital in securing this supply, making sure it is safe and ensuring that poor smallholders can benefit from such opportunities.

Veterinary services, including both their public and private sector components, are at the frontline of prevention and control of animal diseases, including those transmissible to humans. Critical for the effective implementation of this mission is to ensure that appropriate governance and legislation exists to support early detection and response. To limit the spread of emerging or re-emerging diseases, including zoonoses like avian influenza, there is a need to strengthen the capacity of countries to rapidly detect disease and take appropriate emergency actions to eliminate the disease at its source. Immediately identifying and eradicating an emerging disease at source (such as in animals) is the most economical strategy to manage pandemic risks.

The OIE performance of veterinary services pathway

The World Organisation for Animal Health (OIE) performance of veterinary services (PVS) pathway supports the strengthening of national veterinary services, based on the internationally agreed OIE standards on the quality of veterinary services. It can be represented by the diagram in Figure 1.

The first step of the PVS pathway is OIE PVS evaluation, or the 'diagnosis'. This involves a country voluntarily requesting an OIE-trained and certified expert team to conduct a 2–3 week mission to comprehensively evaluate all aspects of their veterinary services using the 'OIE tool for the evaluation of

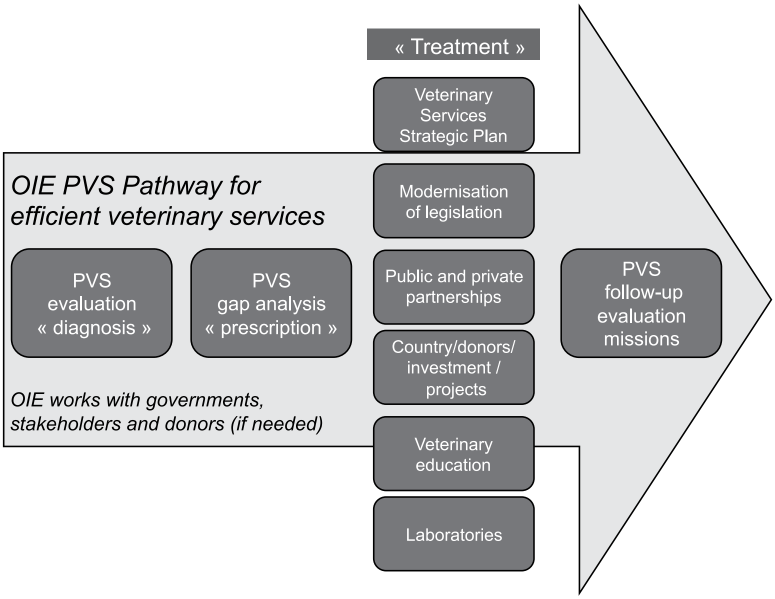

Figure 1. Performance of the veterinary services pathway

performance of veterinary services' (OIE PVS tool). This mission is designed to assist the veterinary services to establish their current level of performance, and to identify gaps and weaknesses regarding their ability to comply with OIE international standards.

The tool measures four fundamental components of national veterinary services:

- human, physical and financial resources
- technical authority and capability
- interaction with stakeholders
- access to markets.

PVS evaluation has been a resounding success with approximately 100 countries voluntarily taking this step as part of the worldwide application of the OIE PVS tool.

The PVS evaluation forms the basis for follow-up support in the form of a (again, voluntary) PVS gap analysis mission—the second step or the 'prescription'. Whereas the PVS evaluation focuses on independent and objective assessment to international standards, the PVS gap analysis mission uses a participatory approach to facilitate country-owned planning based on a careful integration of national priorities, the PVS evaluation results and international standards. The PVS gap analysis goes as far as detailing specific tasks and providing preliminary costings for planned activities.

The third stage, dubbed the 'treatment' phase, incorporates the progression of the planning of PVS gap analysis through to resourcing and implementation within the country to strengthen veterinary services. A suite of support activities are available, including national veterinary services strategic plans using PVS pathway inputs to guide investments by governments and/or partner agency and donor projects, and specific assistance from the OIE in priority areas such as veterinary services legislation, education and laboratories.

The final phase of the PVS pathway incorporates an in-built monitoring and evaluation component to assess progress along the PVS pathway via a PVS follow-up evaluation. The PVS tool is again used to provide consistent measurement against the original PVS evaluation ('diagnosis') benchmark, taking into account the planning, resourcing and implementation activities that have taken place since. Following this, a further gap analysis planning mission can be repeated and thus a 'cycle of continuous improvement' can be developed for sustainable and continuous strengthening of veterinary services. The beginning of a new phase or cycle of the PVS pathway is estimated to be approximately 4–5 years, but this may be shorter or longer depending on case-by-case factors such as internal planning cycles and evolving veterinary services context and needs.

The OIE/AusAID Program for Strengthening Veterinary Services in South-East Asia

With support from the Australian Agency for International Development (AusAID), the OIE launched the OIE/AusAID Program for Strengthening Veterinary Services in South-East Asia (PSVS) in September 2007. This program was initially developed to help countries build capacity in terms of legislation and governance, emergency preparedness and animal health communication. It was also intended to raise awareness of the OIE and its activities among veterinary services workers and stakeholders at a national level.

PSVS has since evolved and now provides additional support for the OIE PVS pathway, outside the defined PVS evaluation and PVS gap analysis missions. It has a particular focus on:

- awareness-raising and advocacy for improved PVS uptake
- national workshops to broaden and deepen engagement
- strengthening veterinary services' preparations for missions
- formally linking the PVS pathway with internal strategic planning processes
- providing assistance in the conversion of the PVS gap analysis to a nationally owned veterinary services strategic plan
- following through to resourcing and implementing the strategic plan and PVS recommendations by governments and/or partner agencies.

The final point may be undertaken through the holding of donor roundtables based on PVS findings and national strategic planning. PSVS has enjoyed good success in South-East Asia towards better realising the PVS pathway and is on track for modelling the outstanding potential for sustainable strengthening of veterinary services available through the OIE.

Conclusion

Veterinary services are now fully recognised as a global public good. This is relevant to their central role in managing rapidly evolving EID (including zoonotic) risks arising from risk factors such as globalisation of travel and trade, urbanisation and habitat destruction, livestock intensification and climate change. The OIE PVS pathway, with additional support through the PSVS program in South-East Asia, provides a useful staged approach with targeted support for the systematic strengthening of veterinary services based on international standards. A vital component for any veterinary services system is veterinary legislation, which needs to provide for minimum key functions relating to good governance of veterinary services. Key legislative provisions are required for the veterinary profession through a veterinary statutory body, covering national disease surveillance and control, trade facilitation and border control, animal production, food safety and aspects relating to veterinary drugs. The OIE has provided publically available 'Guidelines on veterinary legislation' and also offers support to countries through missions dedicated to updating veterinary legislation, with the opportunity for longer term support through the signing of a memorandum of understanding. The OIE will continue to provide support to countries relevant to its core mission of improving animal health worldwide.

Diagnostic capacity for regional emergency infectious disease preparedness

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Emerging infectious disease (EID) management requires data; key data relating to diseases is generated by diagnostic testing. The test result alone is not sufficient for a complete analysis, but it does underpin the confidence that can be placed in the available information on which decisions can be made and actions taken. It follows that there must be confidence in the accuracy of the test result.

The World Health Organization–sponsored Maputo Declaration on Strengthening of Laboratory Systems for public health laboratory support (WHO 2008) contains elements equally applicable for veterinary laboratory services underpinning EID control. In resource-limited settings, several challenges can result in inadequate laboratory systems to support the scale up of programs. These include a lack of leadership and advocacy; human resources, career path and retention of staff; national laboratory policy; strategic planning (budgetary concerns); physical infrastructure; supply chain management; and quality management systems. National governments should support laboratory systems by developing a national laboratory policy to guide the implementation of a national strategic laboratory plan.

Diagnostic testing must be relevant to the purpose of the disease management program for which the testing was commissioned. Knowledge of the diagnostic tests available, what they actually measure, their performance characteristics and their managed reliability in the facility or location where the testing is conducted are all prerequisites for the effective use of testing as a contribution to available data.

This paper gives an overview of the management of diagnostic testing, the potential availability of new test methodologies for EID management and the capacity building required to consolidate, manage and further develop the diagnostic testing capacity of the region.

Quality assurance and confidence in test results

Confidence in test results is a function of the whole management system of the laboratory. Importantly, an accredited quality-assurance system comprehensively covers the laboratory management practices, and is not restricted to test methods and measures of the technical reliability of these (OIE 2008).

A critical management decision is to define the range of purposes for which the laboratory will conduct testing: the diseases; the purposes of testing for each disease; and consequently the test methods that will be needed—serology, antigen or molecular agent detection, isolation or culture of the viable organism, or other more technologically demanding phenotypic or molecular characterisations. The quality-assurance system will then state the policies and procedures regarding the facilities and their maintenance and operation, as well as the staff, their qualifications and skills, and their training.

Laboratories are usually required to be independently audited to international standards as written in ISO/IEC 17025:2005, the World Organisation for Animal Health (OIE) manual (OIE 2011) and other OIE publications (OIE 2008) to assess whether all the requirements have been effectively managed. This process is called accreditation. Usually national governments define the agency with the authority to formally accredit laboratories.

Accreditation relates to individual laboratories but increasingly there is a need for laboratories to operate in networks in which there is community confidence that all participating laboratories can be relied on to get the same test result when the same specimen is submitted for testing. Such networks may be national, providing defined testing services within a country, or international, such as the network of national laboratories for animal influenza testing that is being consolidated in South-East Asia.

The more easily managed approach to help ensure that laboratories in a network report equivalent results is standardisation of the test method, including equipment, reagents and methodology. However, laboratories in networks are frequently supported by different national or subnational jurisdictions. Different governance and management arrangements lead to purchase of different equipment, while different experiences among the staff can lead to the use of different reagents and test methods. A process of harmonisation is needed to deliver the desired outcome of equivalent results from the participants in the network.

Proficiency testing (PT, ring testing or external quality assurance) is the process of distributing panels of samples of unknown status to a number of laboratories that test the samples 'blind' and report their results for analysis by the PT provider. The analysis employs analytical and statistical techniques to ascertain that all laboratories are reporting essentially similar results for each sample, or to identify where results are different from the consensus. The design of the panel can be targeted to assess issues such as sensitivity, specificity and repeatability of testing in each facility. Provision of PT is an aspect of laboratory science that must also be quality assured. There is a new international standard for the accreditation of PT providers, ISO/IEC 17043:2010; it is recommended that PT providers be accredited to, or be working towards, compliance with this standard.

A PT round is an assessment of performance of a particular test at a particular time. The provision of a PT round is time-consuming and hence expensive. As well as preparation of the samples for panels there are the logistics of delivering the panels to participants in different jurisdictions with different requirements for the movement of biological materials, and the subsequent requesting of results, analyses and reporting.

Established processes of internal quality control (IQC) provide laboratories with a measure of test performance every time the test is performed. IQC results should be recorded for comparison with the results of previous test runs, and the data analysed by the laboratory itself to identify trends over time, especially where these indicate a systemic change in test performance.

IQC results can be compared among the laboratories in a network, providing all are using the same reference standard. Such a control reagent is called a network standard or network calibrator. The data is shared among all the laboratories performing the test, collated by an agreed coordinator. Where the results of IQC on the network standard are graphed, participants can see how their performance of the test compares with others. The resulting discussions quickly lead to technical improvements and closer harmonisation.

Capacity building for quality assurance (QA) for laboratories in a network will involve assistance in developing and expanding the ISO/IEC 17025 quality-assurance system, refinement and harmonisation of test methods, the provision of PT and the active development of systems of networked QA based on network calibrators.

Capacity building: challenges, approaches and ongoing needs

The assessment and management of a reliable testing capability is a recognised component of the OIE's program for evaluating the performance of veterinary services. Capacity building at any laboratory is a partnership between laboratory management and an external provider of managerial and technical expertise. Capacity building will not reach its full potential if it is seen by the laboratory director and staff as technological support for a few test methods rather than part of the overall management strategy. Comprehensive capacity building will address the various aspects of laboratory management and test performance and management that are covered in the international standards such as ISO/IEC 17025:2005, including biorisk management.

A useful starting point is a laboratory gap analysis, which will allow the laboratory to assess its testing capability against the defined outputs required by the governing jurisdiction, including comprehensive assessments of conformity with the international standards that underpin accreditation. The gap analysis should be a partnership between laboratory management and an external source of expert advice. This is the approach that has been attempted in recent network-building activities in South-East Asia.

If the impetus for the capacity building is a specific disease threat such as avian influenza, pandemic influenza H1N1/2009, foot-and-mouth disease or other zoonotic EIDs, it is likely that project activities will focus on the delivery of reliable test results for the management of that situation. However, these activities can be aligned with the broader goal of developing and maintaining an accredited QA system and conducted with that final goal in mind. Expectations about the progress that can be made in defined project time frames should be carefully managed and, conversely, objective systems of monitoring and evaluation should assess that achievable objectives are being met.

Much public money is spent on training, either on specific test methods or other aspects of laboratory management. It is one of the key points of this paper that a stand-alone training experience will not effectively deliver capacity building in the current regional context. Training experiences are best delivered within a network of enduring, appropriately focused support. Science does not flourish in isolation; scientists across the world communicate with and support each other. Capacity building includes developing the opportunity for such support in circumstances where laboratory personnel might otherwise be isolated from the advice of others with more experience.

Training in a facility where systems are working well is useful to demonstrate either best practice or acceptable benchmarked approaches. Laboratory visits by external advisors help adapt international knowledge and standards to the particular local physical and social environment. Facilitating such visits is a necessary part of network development.

Workshopping among colleagues undergoing similar capacity-building activities is a useful means of sharing experiences, working towards the definition of common regional goals and keeping network members abreast of regional and international developments with respect to diseases of interest and new technologies.

Foreseeable needs and opportunities for different test methodologies

New and improved diagnostic testing technologies are continuously being developed. A responsibility of laboratory management and the veterinary service is to define policy about which test methods will be used for official purposes, and which technologies may be incorporated into national disease management strategies in the future. Newer technologies must be assessed for fitness for purpose within a nationally agreed strategy, validated and managed under a quality-assurance system.

Three trends may change the way testing can be conducted. Testing for more than one agent or analyte can be conducted simultaneously. Multiplexing is one term that describes this approach, array technology is another. Nucleic acid sequences may be targeted in new forms of molecular detection or, alternatively, specific proteins may be identified—usually antigens or antibodies. The likely infectious organisms in a specimen will be identified from a wide range of possibilities, rather than having individual tests for individual agents. Possible applications are in index case diagnostics for EIDs, in surveillance of animal populations for a range of organisms of possible biosecurity concern, and in food safety screening procedures once the technologies are sufficiently validated.

EID management is requiring more information more quickly regarding the infectious agent in an outbreak. Beyond identification, serotyping and pathotyping, information is required on molecular epidemiology; whether significant molecular drift or other changes have occurred; and whether the isolate has genetic markers associated with characteristics such as antiviral resistance, virulence and transmissibility among different host species. Experience is being developed with different approaches to rapid whole-genome sequencing and the supporting bioinformatics capabilities. Highly pathogenic avian influenza H5N1 and the pandemic influenza H1N1/2009 have confirmed that effective disease management transcends national boundaries and capabilities and the involvement of international reference laboratories and trusted networks of expertise is critical.

Point-of-sampling tests offer more rapid availability of test results. Submission of specimens to a distant laboratory can be a constraint to timely responses in an outbreak if there are logistical problems delaying testing and reporting. As the reliability of technologies for testing away from the laboratory improves, their uptake will increase. The challenge is to identify tests that can be relied on for specific purposes and then manage the testing process in a quality-assured manner. Established laboratories have the experience in managing quality-assured diagnostic testing and can assist in the introduction of point-of-sampling testing. Again, this will be a focus of capacity building.

Conclusions

Laboratory management first involves defining the purposes for which testing will be conducted, the diseases in scope and the test methodologies to be supported. Any analysis of laboratory capability will assess whether these issues have been addressed and communicated effectively to all stakeholders so that a shared understanding and common purpose exist. A quality-assurance system meeting international standards will provide the management framework for delivery of services.

Laboratory testing is crucial to effective management of EID threats. Society has a right to expect that the farming of animals to meet its needs for food and other products or services will not result in situations that are a threat to the community. Systems of diagnosis and surveillance, underpinned by reliable test results, will increasingly be developed to deliver such assurances. Laboratory capacity building will continue to deliver ever-increasing levels of capability to meet these demands.

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Animal health communication in South-East Asia

Domingo Caro III, John Edwards, Kate Fitch, Anne Surma and Subhash Morzaria

Despite increasing recognition of the importance of communication in animal health, especially in recent zoonotic disease outbreaks, some studies have showed that there are gaps in its conceptualisation and practice (Alders and Bagnol 2007; Hickler 2007). This research project aims to define animal health communication and propose a model of its practice.

The aim of agricultural extension is to disseminate information and strategies produced by public researchers to farmers and other stakeholders (Zhou 2010). The theoretical framework governing this field is Roger's Diffusion of Innovations (Waisbord 2001; Mefalopulos 2003, 2008; Zhou 2010). The Diffusion of Innovations theory follows the transmission model of communication or top-to-bottom communication. The theory states that development is transferred through channels from one country to another. However, a number of studies have disputed the effectiveness of this approach to development and communication, citing the pervasiveness of underdevelopment and the authoritarian nature of the theory (Craig 1999, 2007; Waisbord 2001; Mefalopulos 2003, 2008; Family Health International 2002; Inagaki 2007; Servaes 2008). Development communication was later conceptualised from agricultural extension, not only with the intent of informing or transferring knowledge, but also for improving living standards (Waisbord 2001; Mefalopulos 2003, 2008; Manyozo 2006; Servaes 2008). A recent definition of development communication is:

> a social process based on dialogue using a broad range of tools and methods. It is also about seeking change at different levels, including listening, building trust, sharing knowledge and skills, building policies, debating and learning for sustained and meaningful change. It is not public relations or corporate communication (Mefalopulos 2008).

Research activities

The research was conducted between 2006 and 2010 using quantitative and qualitative methodologies (Sarantakos 2005). The quantitative phase of the research consisted of a knowledge, attitudes and practices (KAP) survey, while the qualitative phases used participatory tools in the investigation of factors affecting animal health communication.

Among the study participants of the KAP survey were farmers, traders and animal health workers from Cambodia, Lao PDR and Vietnam. These Greater Mekong Subregion (GMS) countries were selected because they represented low-, medium- and high-income earning countries, respectively. A combination of purposive and random sampling was used to select study participants. Local partners played a key role in the planning and implementation of the survey.

Some highlights of the KAP survey include the following:

- Despite extensive public awareness campaigns in the GMS countries, there is some awareness but poor knowledge on trans-boundary animal diseases such as classical swine fever, foot-and-mouth disease (FMD) and highly pathogenic avian influenza.
- There is a satisfactory level of technical awareness among the village animal health workers (VAHWs) but poor understanding of trans-boundary disease diagnosis.
- Farmers recognise the need to control and eradicate trans-boundary diseases; however, they do not see it as an urgent need.
- Study participants prefer television as a medium but have more exposure to radio.

The KAP survey gave an overview of what is happening in the field; however, it is important to know why and how these factors affect animal health communication. Therefore, further fieldwork was conducted in the three countries. Participatory tools such as transect walk, focus group discussions and interviews were used. The areas were chosen because of continuing efforts to establish FMD-free zones in the GMS. Results from the exploratory fieldwork showed that a number of factors affect animal health communication, including communication strategies, motivation to follow animal health messages, trusted communication channels, feedback/evaluation, government capacity, technical skills, funding and grassroots capacity.

The exploratory fieldwork confirmed some findings of previous studies such as the need for effective communication strategies and the existence of misunderstanding between the national animal health organisations and grassroots farmers (CARE International Vietnam and Quality of Life Promotion Centre 2005; Alders and Bagnol 2007; Hickler 2007). The role of volunteer animal health workers was also found to extend beyond delivering animal health services. The VAHWs engage farmers and other stakeholders to improve their behaviour in animal health. Although the exploratory fieldwork was satisfactory, there was still a need to further investigate why the factors affect communication in animal health. Methods were validated for use in further fieldwork.

The final field study took place in early 2010, this time in Cambodia and Laos. These countries were chosen because they have volunteer animal health services, unlike Vietnam which has paid animal health workers at the community level. The study participants also included national animal health authorities. The study confirmed that VAHWs play an important role in the delivery of services, especially in isolated communities. The role that they play in engaging a number of stakeholders in their area is invaluable because most remote areas in the GMS have their own language or dialect. Language was one of the factors that emerged as a key indicator in whether stakeholders will engage in any animal health campaign. Farmers and traders were willing to participate; however, they would rather that the government left them alone to manage their animals. They were willing to participate in government-initiated animal health campaigns if it cost them nothing, and there were some who claimed that they would be willing to pay a small amount for some services.

Another factor is the risk perception among the stakeholders, which depends on the nature of the disease; farmers and traders tend to put off the treatment or reporting of endemic animal diseases compared to potentially zoonotic diseases. Another level of motivation among stakeholders that would potentially change their motivation to report or give action is the cost that is associated with the disease. Generally, the more costly the disease or the animal involved, the better the reaction from the farmers or traders.

Conclusions

This research has contributed to an understanding of the implementation of animal health services in the region. It confirmed that VAHWs play a key role in the implementation of animal health strategies and engagement of various stakeholders. They are the gatekeepers at the village level, and maximising the training that VAHWs get will likely result in better delivery of animal health services, especially in remote areas.

Recent advances show that participatory approaches are more effective when addressing issues at the grassroots level. This has been the case in animal health where participatory approaches are increasing in use as an informed choice (Catley and Croxton 2001). The research showed that most of the study participants were willing to contribute to animal health planning, but acknowledged that they would need expert guidance to participate in such a team. Some critics argue that the participatory approach is idealistic and out of touch with reality. A purely participatory approach, where various stakeholders equally participate and contribute to the solution, might be impossible, but it is important to consider the opinion of all stakeholders, especially for animal health. There is existing indigenous knowledge on animal health that is yet to be tapped into, especially among grassroots stakeholders in remote areas. This is an important asset, particularly in regions where government services and personnel can only reach limited numbers of the population.

A purely participatory approach to animal health programs has yet to be investigated or implemented, but there are good opportunities to investigate the implications of such an approach. Participatory approaches have been used in economic development programs; however, development of animal health strategies is a different field. Scientists are ultimately considered the authority, but considering stakeholders in the field also hold the key to the success of any animal health strategy. This might be the time to seriously consider investing in a genuinely participatory approach to animal health, or even investigating the implications of a participatory approach in animal health.

This research initially extended the United States Department of Health and Human Services' definition of public health communication (National Cancer Institute 2003, 2005), and can be reworded as

> animal health communication is the study and use of communication strategies to inform and influence individual and community decisions to enhance animal health or prevent, control and eradicate animal diseases.

Based on interviews, field discussions and surveys, animal health communication is conceived in a number of ways in the field. It is the communication among animal health authorities, among grassroots stakeholders and between these two groups. It is composed of horizontal and vertical communication among various stakeholders who perceive that it will only work if it is backed by strong policies and funding. Strong policy and funding commitments are needed but have yet to be implemented.

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Making sense of local knowledge and indigenous practices on health and biosecurity risk management

Elaine Llarena, John Edwards, Anne Surma, Kate Fitch and Carolyn Benigno

The potential for zoonotic emerging infectious diseases (EIDs) to spread worldwide is immense. Geographical boundaries can be uncertain and management of disease crises, biosecurity and health risks is a huge task that requires cooperation and understanding from many parts of the public and private sectors. A glimpse of this has been seen over the years during epidemics, including the bovine spongiform encephalopathy or mad cow disease outbreak in the United Kingdom, Hendra virus outbreaks among horses in Australia, Nipah virus spread in Malaysia and Singapore, and the severe acute respiratory syndrome (SARS) outbreaks in Asia. In the last decade, highly pathogenic avian influenza H5N1 (HPAI H5N1), or 'bird flu', outbreaks have also been a focus of global attention.

These zoonotic EIDs have predominantly affected countries in South-East Asia. Why is this so? One obvious factor is the way animals are raised, slaughtered and prepared for food consumption. There are certain animal-rearing practices and human health beliefs in countries in the region that need to be recognised before control programs can be designed. Governance and institutional systems also function differently in countries in the region, affecting the enactment of policies to support biosecurity risk management and preparedness.

International non-government organisations, donor agencies and other humanitarian organisations have supported countries in the region to help eradicate HPAI H5N1. Assistance is given through technical and funding support necessary to build local capacity for disease control, as well as to institute preparedness plans and manage health and biosecurity risks. Resources are poured into the establishment of emergency plans and protocols to prepare for a possible influenza pandemic to minimise global catastrophe.

Rationale

Communication is an integral element in advocating health issues, promoting the public agenda in health programs, and addressing health and biosecurity risks. Experiences from previous zoonotic EID outbreaks, such as SARS, Nipah virus and HPAI H5N1, prove the importance of engaging different stakeholders across levels (i.e. international, regional, national and local communities) through effective communication. Communication makes use of different approaches and channels, such as the mass media and multimedia as well as other technological innovations and indigenous means, to disseminate information and increase awareness of specific aspects of the program. Communication may be also viewed as a process for development and social change in disease prevention and control.

In EID events, the proactive engagement of different stakeholders at all levels through communication is more emphasised, particularly in disease crises and health risk management. Outbreak communication, crisis communication and risk communication are the subdisciplines widely implemented to address health communication appropriately. Other specialised communication approaches are also employed; for instance in the avian influenza/pandemic influenza preparedness program, the important role of communication is strongly recognised, especially for behaviour change, given the cultural and socioeconomic issues in disease mitigation (Chitnis and Monsoor 2007).

Communication between animal and public health sciences is required for more effective management of EIDs. The commitment and continuous involvement of all stakeholders, communication of effective messages without delay, and keen promotion of the long-term benefits of adhering to health standards and appropriate practices are some of the key elements to be integrated into the biosecurity and health agenda.

There are several additional challenges preventing effective communication from changing the behaviour of stakeholders. Also, improvements are necessary for effective crisis and risk communication management to intensify stakeholders' commitment to, and participation in, biosecurity and health management initiatives. These challenges include:

- gaps in the knowledge of health risks and existing practices of stakeholders
- under-appreciation of technical expertise of communication specialists
- difficulties in integrating practical knowledge and practices with more appropriate communication approaches to biosecurity and health
- poor judgment and lack of stronger resolve among those involved in the communication aspect of disease emergencies, jeopardising the transparency of actual scenarios, especially in disease crisis situations.

This study investigated the cultural, social and institutional factors that affect crisis and risk communication in response to zoonotic disease emergencies and management of health and biosecurity risks. We explored methods for communication management of zoonotic EIDs in South-East Asia. While all levels of stakeholders were investigated, community interventions at the grassroots level were the primary focus.

Two central questions were addressed:

1. What are the sociocultural drivers and institutional factors that affect effective crisis and risk communication management in response to zoonotic EIDs in South-East Asia?
2. Based on the field study experience and secondary data gathered, what are the emerging issues and gaps relevant to facilitating appropriate crisis and risk communication strategies?

Subsequently, the research determined which communication approach is relevant, considering the 'One Health' concept; which approach is appropriate to implement, especially at the community level, for zoonotic disease emergency preparedness; and what is the best practice for managing health and biosecurity risks.

The major output of the research is the Integrated Communication Framework for Emerging Infectious Disease (ICF4EID). This communication paradigm is a combination of three dominant communication frameworks to address zoonotic EIDs in a South-East Asian context: behaviour change communication, risk communication and communication for social change. The ICF4EID is expected to be useful in decision-making and policy formulation, to manage veterinary public health programs and to improve communication of health biosecurity risks to stakeholders.

Observations

Multidisciplinary approach to zoonotic EID research

This study is appropriately placed as a multidisciplinary research project that primarily looks into crisis and risk communication in response to zoonotic EIDs—a goal shared among scholars from the health sciences and social sciences. For example, multidisciplinary studies support continued scientific discoveries into the characteristics of EIDs and how this information is processed into timely and more practical applications to address disease control and prevention.

The consequences of EID outbreaks challenge transnational politics and governance, the economy, food security, indigenous knowledge, and practices entrenched in cultural traditions and behaviour change. Therefore, it is imperative for social scientists to be involved in the development of communication strategies for EID preparedness and management. This research addressed the profound need for communication research and a deeper understanding of South-East Asian sociocultural contexts to develop alternative methods of addressing biosecurity and health risks relating to EIDs.

Future studies into interdisciplinary approaches should also be explored, as complex research problems are apparent, especially in relation to sociocultural impacts of biosecurity and health risks relevant to zoonotic EIDs (ICMR Bulletin 2004; Fozdar 2008).

Support of the 'One Health' paradigm

Globalisation is a major precursor to changes in the health landscape, both at the international and national level, so it is inevitable that it would affect how EIDs are managed. In recent times, there has been considerable interest in the relationships between human health, animal health and the environment, leading to development of the One Health concept to advocate a holistic approach to addressing EIDs.

The ability of a disease to spread rapidly, over a wide area, and to cross species is a major concern. The One Health view is expected to address the global concerns of zoonotic EIDs while considering the different situations in affected countries. Integrated global health structures are intended to influence community health at the village level, yet community health situations and local biosecurity practices like hygiene, handling of food and animal rearing could become global health concerns. This was apparent in the field data gathered. The study gave a practical view of what is happening and local conditions at the community level, which is significant information for managing diseases in developing countries in South-East Asia.

Recommendations based on sociocultural and institutional settings

As the research considered the sociocultural aspects and institutional settings in managing health and biosecurity risks, it also revealed the communication processes involved. One of the strengths of the research is highlighting the relevance of Asia-centric communication scholarship. Miike (2002) defines Asia-centric communication scholarship as

> a theoretical system or a school of thought in communication whose concepts, postulates and resources are rooted in, or derived from, the cumulative wisdom of diverse Asian cultural traditions.

It considers Asian concepts, values, language use and religious beliefs in making sense of the usual practices and understanding of the local people. The Asia-centric perspective will contribute to further understanding of sociocultural norms and provide practical recommendations to address effective communication and behaviour change in disease control. It will also help to engage the local community so that they may find relevance in the new ideas and technologies presented to them.

Conclusions

Communication is an integral part of biosecurity and health risk management, and communication research with a focus on sociocultural attributes is a fundamental part of this management strategy and complements technical research on EIDs.

The Asia-centric communication approach described in this paper has been named the Integrated Communication Framework for Emerging Infectious Diseases (ICF4EID), which embraces scholarship and empirical research on EIDs. This conceptual–operational framework is predicated on the need to understand local practices and systems in order to influence positive social change in managing health and biosecurity risks. The ICF4EID can be used as the basis for future communication research in South-East Asia.

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Disease control programs

Cooperation of livestock owners and communities is essential for effective disease control. (Photo: Sieng Socheat)

South-East Asia and China Foot-and-Mouth Disease Campaign 2020 Roadmap as a model for regional development

Ronella Abila, Gardner Murray and Sharie Michelle Aviso

The South-East Asia and China Foot-and-Mouth Disease Campaign (SEACFMD) 2020 Roadmap (OIE 2007) provides strategic direction for achieving freedom from foot-and-mouth disease (FMD) with vaccination in South-East Asia by 2020, and maintaining freedom in designated free countries and zones. The SEACFMD, which has been underpinning eradication efforts since 1997, provides a valuable model for the regional coordination and management of major trans-boundary and zoonotic diseases. In planning future regional disease prevention and control programs and the next phase of the SEACFMD, it is useful to review from a SEACFMD perspective some key issues and opportunities for the animal health sector in South-East Asia.

Overview of the SEACFMD Campaign and Roadmap 2020

The South-East Asia Foot-and-Mouth Disease Campaign (SEAFMD)[1] was formally established in Bangkok in 1997 under an agreement between the World Organisation for Animal Health (OIE) and the Kingdom of Thailand to create a regional coordination unit (RCU). The campaign is in the last stage of phase 3 of five phases, with phase 4 scheduled to commence on 1 July 2011. The Australian Agency for International Development (AusAID) has been the primary donor for the SEAFMD since 1997, contributing a total of A$6.5 million over 14 years. Other donors include France and Japan. National governments have also supported the campaign as have organisations including the Food and Agriculture Organization of the United Nations (FAO) and complementary-funded projects such as the European Union/OIE Highly Pathogenic Emerging Disease Program. The Government of Thailand is the other major donor providing in-kind support to the SEAFMD-RCU, part of the OIE Sub-Regional Representation, housed within the premises of the Department of Livestock Development.

The SEACFMD concept is that, given the highly infectious nature of FMD, the contiguous borders and cross-border movements in much of Asia, control and eradication planning requires a sophisticated coordination approach recognising that individual countries have the responsibility for managing their own programs. Each phase has shared similar long-term goals, but the process of development of each phase has been iterative, and, while having the same overall objectives, the nature of activities in member countries has varied depending upon production arrangements and socioeconomic circumstances. Phase 4 is seen as the critical expansion phase to achieving regional eradication of FMD with vaccination by 2020 and, importantly, maintaining freedom in designated free countries and zones. To this end, the campaign now includes all 10 Association of Southeast Asian Nations member countries and China, which has been involved since 2004, and the name has been changed to reflect this inclusion to the SEAC(hina) FMD Campaign. China is now more actively involved in the broader range of SEACFMD work. The updated SEACFMD 2020 Roadmap is currently in final publication.

[1] The program changed its name in 2010 to SEACFMD, with the inclusion of China.

Long-term regional and bilateral support to build animal health services and capacity

The SEACFMD, while focused on a single disease, FMD, is attributed a high degree of effectiveness because it is underpinned by a broad animal health systems-strengthening approach that has been used by countries in preventing and controlling highly pathogenic avian influenza (HPAI) and classical swine fever. However, there is also a strong realisation from the OIE and AusAID that a regional campaign, while important, will not lead to successful eradication if not complemented by well-resourced national FMD plans. More successful eradication efforts result from a combination of long-term regional and bilateral support, as in the Philippines where AusAID provided A$9.2 million to support the Philippine FMD eradication efforts from 1996 to 2009 with bilateral country-level support and implementation through the FAO. The context of tackling FMD in mainland South-East Asia, with shared land borders, is also more challenging compared to previous successes with archipelagos (i.e. Indonesia and Philippines) and is highly dependent on trans-border collaboration on animal movements.

This issue is particularly relevant for the least developed countries in South-East Asia (e.g. Burma [Myanmar], Cambodia, Lao PDR) where weak national animal health systems are constrained by insufficient physical, human and financial resources. SEACFMD objectives, particularly in those countries, will not be met unless additional and substantial in-country support can be provided to subsidise the high costs of vaccines and support programs. AusAID currently does not have bilateral FMD programs in these countries and considers these priority countries to reach. A new program, which at the time of writing is at the concept stage, has been developed for this purpose. The program is called OIE-STANDZ (Stop Transboundary Animal Diseases and Zoonoses)[2] and will include three linked components: the SEACFMD, a capacity-building activity for veterinary services and 'One Health'.

[2] Sancho J., Esser A., Murray G., Abila R., Black P. and Escolar R. 2011. Stop Transboundary Animal Diseases and Zoonoses (STANDZ) initiative: draft design document. AusAID Health Resources Facility.

The geographic focus on South-East Asia and the importance of strengthening national veterinary services systems underpinned the introduction of the Program for Strengthening Veterinary Services (PSVS) in 2007 (see Abila and Stratton 2012). Since OIE maintains the global standards on animal health and veterinary services, the OIE PVS pathway is accepted as the global process, containing standard OIE tools, to assist countries reach international veterinary services standards. National veterinary service systems that meet OIE international standards will have stronger capacities to prevent and control trans-boundary animal diseases (e.g. FMD, HPAI, porcine reproductive and respiratory syndrome) and arrest zoonotic diseases (e.g. rabies, HPAI, H1N1 2009 influenza) at source.

Investment in strengthening veterinary systems is economically attractive for national governments and donors. A 2010 PSVS study assessed the economic attractiveness of investing in veterinary services activities by quantifying their benefits in reducing the frequency of emerging infectious disease (EID) episodes, along with improved management of endemic and food-borne diseases. Benefit:cost ratios of between 3.7 and 2.1:1 were calculated for the Philippines and Vietnam, respectively.

Building the veterinary and animal health workforce

In countries such as Laos, where investment in the animal sector has not been optimal, the major issues include an inadequate number of trained animal health personnel and the need to up-skill and improve competencies. In countries such as Vietnam, which have increased training capacity, the more challenging issue is to create and fill positions where they are needed to meet workforce needs. The animal health sector (like other sectors) needs to look at its skill mix as it addresses workforce constraints.

Developed countries are beginning to rely more heavily on the paraveterinary workforce, including technicians, technologists and nurses, to complement and support veterinarians to deliver animal health services that are affordable and effective. Programs for veterinary and paraveterinary professionals are also changing in scope to include more emphasis on gender and other social and economic variables with the aim to develop a workforce that is more adaptive in its approach and more able to work in multidisciplinary teams. There is also huge variation in the development of veterinary education among countries, and analysis by country, based possibly on PVS evaluation and gap analysis reports, could be undertaken to clearly identify and prioritise workforce issues.

The STANDZ program concept proposes, among other things, medium- to long-term strategies to support the development and adoption of core curricula, progress opportunities for 'twinning' animal health services between countries, and the funding of PVS activities.

Disease emergence in South-East Asia and the need to build animal health services capacity

The Fifth Global Progress Report on Animal and Pandemic Influenza (United Nations and the World Bank 2010) recognises that a high proportion of infectious diseases in humans come from animals, that these zoonotic diseases have high economic costs, and that outbreaks that do occur—such as HPAI H5N1 and pandemic influenza A (H1N1) 2009—have major political, economic and health consequences. The report also emphasises that much needs to be done to improve veterinary services in many countries and that if investments in animal health systems are insufficient, there is an increased risk of further disease outbreaks.

South-East Asia is recognised as a hot spot for EIDs, particularly zoonoses. Surveillance systems, as the backbone of disease control, need to be part of a more comprehensive monitoring and evaluation system capable of anticipating the emergence of infectious disease and supporting outbreak responses. This in turn requires building new competencies in the underlying systems and workforce, to be adaptive and responsive as early as possible.

Monitoring and evaluation

Reviews of regionally coordinated initiatives identify an inherent difficulty in delineating regional- and national-level action for achieving joint outcomes and impact. Failure to link activity to higher level impact and socioeconomic measures hampers advocacy initiatives—which in turns leads to low availability of resources, difficulties in scaling up and limited sustainability of gains at the country level. Monitoring and evaluation capacity and systems need to be strengthened across regional parties and national counterparts, and include the development of indicators and baseline data.

FMD, trans-boundary and zoonotic diseases have differing impacts on women and children that need to be evaluated and understood before further developing animal health systems and education and training programs. Gender-specific dimensions of disease prevention and control are important for improving food security, nutrition and income of rural communities that are dependent on livestock.

Conclusions

The SEACFMD 2020 Roadmap is about to commence phase 4 of a five-phase program towards freedom from FMD with vaccination in South-East Asia by 2020. The future development of the campaign needs to focus on strengthening animal health and veterinary services capacity within countries. This will require continuing investment in regional and bilateral coordination and support for disease prevention and control, education and training, workforce development, and program monitoring and evaluation. These areas of investment are considered part of STANDZ, a program being developed by OIE and AusAID. The potential success of STANDZ will be enhanced by complementary programs funded by the European Union and United States Agency for International Development (and potentially ACIAR), and managed by the OIE Sub-Regional Representation.

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Village-based approaches to biosecurity in the Mekong region

Peter Windsor, Syseng Khounsy, Suon Sothoeun, Sonevilay Nampanya, John Stratton, Luzia Rast, Lynn Henry and Russell Bush

Cambodia and Lao PDR are strategically placed to capitalise on the growing demand for meat in adjacent countries, which is an opportunity to address rural poverty. However, there are significant constraints to large-ruminant production in these two countries, including endemic diseases; poor husbandry and management practices; lack of financial skills of farmers; poorly trained field staff; inadequate resources; and difficulty of access, particularly in the northern provinces of Laos. A large livestock development project (LDP) in northern Laos (Khounsy 2012) is addressing this issue using participatory action research to improve farmer learning and adoption rates of interventions to address large-ruminant production constraints. The training of inexperienced regional livestock extension workers to disseminate knowledge and skills to farmers is required, as is applied research to identify which of the many potential interventions can best improve large-ruminant production.

In 2006, ACIAR commissioned the University of Sydney to identify research priorities for the development of the beef industry in Cambodia and Laos (Windsor 2008). The research examined both the economic drivers for large-ruminant production and the question of farmer receptivity to project interventions. The research confirmed that momentum for change was building as a consequence of the increasing adoption of forage technology by smallholder farmers, enabling large-ruminant fattening for the expanding demand for better quality red meat in the region. Increasing returns from this trade has provoked interest by early-adopter farmers in animal health risk management to protect the increasing value of their emerging large-ruminant enterprise. This presented an opportunity to address biosecurity needs that may assist trans-boundary animal disease control at both the village level and through the supply chain, particularly for foot-and-mouth disease (FMD).

The process led to a large-ruminant health and husbandry research project proposal for each country, using similar methodology. A 3-year longitudinal survey of morbidity, mortality and productivity parameters is measuring changes to productivity as a suite of interventions is introduced. Project AH/2005/086 began in July 2007 in southern Cambodia, with the in-country project team led by Dr Suon Sothoeun based in Phnom Penh. Project AH/2006/159 began in May 2008 in northern Laos, with the in-country project team led by Dr Syseng Khounsy based in Luang Prabang. These projects aim to identify which of the many potential interventions are able to be adopted by farmers to improve large-ruminant productivity, including strategies to improve animal health, nutrition, reproduction management and marketing. This paper reports on preliminary findings from these strategies and outlines the role of participatory workshops in capacity building for improved cattle and buffalo production and health, particularly with respect to FMD and the development and testing of village-level biosecurity interventions.

FMD is considered the most significant global trans-boundary livestock disease, with major economic impacts on trade and food security due to ease of spread between countries, compromising international trade in livestock and their products (Rweyemamu et al. 2008). FMD also has major social impacts in developing countries, particularly in South-East Asia. At the village level, FMD significantly reduces the value of large ruminants for sale and for their draught power. Their reduced weight decreases the availability of meat for local consumption and their value as the major store of rural wealth.

FMD is endemic in Cambodia and Laos with major outbreaks common, particularly in hot spots where recurrent outbreaks are recognised, such as Xieng Khuang in Laos (Nampanya et al. 2010; Rast et al. 2010). Plans for the eventual global eradication of FMD (Rweyemamu et al. 2008) require a concentrated effort in the Mekong region and a roadmap for regional eradication has been developed by the South-East Asia and China Foot-and-Mouth Disease Campaign (Abila et al. 2012). It is appropriate that all large-ruminant health and production projects in the Mekong region consider the risk of FMD incursion and the need to develop appropriate control options.

Research projects

The ACIAR 'best practice' large-ruminant health and husbandry projects in Laos and Cambodia aim to:

- establish disease limitations
- trial interventions to prevent diseases (including biosecurity) and improve production
- assess farmer knowledge of large-ruminant health, husbandry and marketing
- identify opportunities to improve the cattle and buffalo supply chain and identify drivers for change.

The objective is to find which technical solutions are appropriate for extension, such as vaccination programs or internal parasite management. More importantly, the project will encourage adaptive social or behavioural change, due to knowledge-based interventions, that improve productivity and biosecurity. It uses a 'whole-farm approach' that incorporates strategies to improve all key aspects of the production system and is designed to impact initially at the rural community level. Using participatory research, the project will compare the impacts of a series of interventions in 'high-intervention' compared to 'low-intervention' villages. Data from additional surveys on farmer attitudes to improving large-ruminant production, plus their knowledge of biosecurity, risk of transmission of trans-boundary diseases and large-ruminant health and production, have been used to formulate a series of seven 'train the trainer' workshops. These workshops involved project staff from provincial and district offices of the Cambodian Department of Animal Health and Production and Lao PDR Department of Livestock and Fisheries, and had additional support from the Crawford Fund. They covered a broad range of topics including animal health, biosecurity, nutrition, forage implementation and management (including bagged silage), reproduction, marketing and extension. The workshops on health and biosecurity identified weaknesses in disease investigation and enabled a detailed case study of an FMD outbreak affecting all villages in the Pek district of Xieng Khuang province in Laos (Rast et al. 2010). The workshop on biosecurity facilitated a detailed discussion on the process of identifying disease risks with farmers and formulating a village-level biosecurity plan or 'wish list'. To improve village-level biosecurity, key interventions included animal identification; housing and isolation; vaccination and treatments; movement controls; and public awareness. Consideration of endemic diseases, particularly haemorrhagic septicaemia and, potentially, fasciolosis, is also required to ensure the biosecurity program maintains credibility.

To enable research findings to be scaled up usually requires participatory approaches to extension. Cross-visits have been found to be powerful in promoting the uptake of forage technology between project sites. Other approaches, such as digital stories, are being considered, to help farmers implement additional interventions. It is important that the impact of these is measured. Knowledge surveys at the start, middle and end of the project will be analysed alongside data from the longitudinal surveys on health and production parameters to gauge the degree of learning and uptake of biosecurity interventions associated with the knowledge gaps (Nampanya et al. 2010).

Biosecurity planning

A village-level biosecurity program was developed in a workshop for LDP trainees in Luang Prabang, Laos, in July 2009. The workshop was designed to 'train the trainers' in how to develop a biosecurity plan, using the following exercises:

- Exercise 1: Review disease knowledge
- Exercise 2: Review disease spread
- Exercise 3: Identification and assessment of disease risk
- Exercise 4: Response to disease risk
- Exercise 5: Development of biosecurity programs with farmers in project villages.

For a village-level biosecurity program these exercises require:

- movement controls: prevent introduction of disease by quarantining introduced animals, isolating housing, and avoiding contact between infected and uninfected stock and other sources

of infection, including thorough cleaning and possibly disinfection of vehicles
- vaccination: provide prophylaxis by ensuring vaccines are available and used regularly and correctly
- surveillance: ensure rapid reporting of disease outbreaks by village veterinary workers and encourage confirmation of disease diagnosis
- public awareness: promote risk assessment through knowledge of current disease outbreaks and risk of traders.

This process should empower farmers with group participation in identifying risk factors, then group discussion of issues, leading to broad understanding and agreement on interventions to use. The key intervention is a shared plan, with agreement on resources required such as posters, case studies (digital) and perhaps a broader district or provincial strategy (e.g. School On the Air). The ultimate test of the public awareness program is an ability to prevent disease without vaccination.

Impacts of the project

At the completion of 2 years (Laos) and 3 years (Cambodia) of the projects, it is appropriate to consider their early benefits. Discussion with the village chief at Ban Nong in Xieng Khuang, Laos, identified three benefits:

- better calf survival, as a result of the control of *Toxocara vitulorum*
- prevention of FMD by vaccination
- provision of forages to improve nutrition and save labour to feed livestock.

In Cambodia, there has been a significant introduction of forages, partly to meet the year-round need to fill the gross energy deficiency, and some spontaneous scale up is occurring. The progress in Laos is less consistent, with greater variation between provinces in adopting interventions. This finding is not surprising given there is significant variation in knowledge between provinces as determined in the knowledge survey (Nampanya et al. 2010).

The future of village-level biosecurity

The eradication of FMD in the Mekong is likely to be very difficult for a number of reasons, including:

- the porous international borders where the ‘informal’ international trade of animals is ‘facilitated’ rather than regulated
- a lack of established industry stakeholders for driving a private/public partnership that can share leadership with government and more readily initiate policy
- general reliance on vaccination strategies and a ‘top-down’ institutional approach with substantial deficiencies in disease surveillance, reporting and emergency disease response capacity, including access to vaccines.

This situation suggests that in addition to improving the availability and strategic use of vaccination, a ‘bottom-up’ approach to disease control is needed that can facilitate adaptive change in the behaviour of livestock owners and other stakeholders to reduce the risk of disease. Key steps include:

- development of a readily adopted village-level biosecurity program
- testing of the village-level biosecurity program in FMD hot spots
- widespread promotion of the successful aspects of the program through a strategic public awareness program
- assessing the extent to which improved smallholder farmer knowledge of disease and biosecurity can deliver widespread reduction and elimination of FMD and other diseases in rural communities of the Mekong.

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Balancing endemic and epidemic disease priorities

Kyaw Naing Oo

Countries in the Mekong are home to a long list of endemic diseases such as foot-and-mouth disease (FMD), haemorrhagic septicaemia (HS), anthrax, brucellosis, contagious bovine pleuropneumonia, tuberculosis, classical swine fever (CSF), Newcastle disease, infectious bursal disease and rabies. These diseases can be endemic, epidemic, trans-boundary animal diseases and, in some cases, zoonotic, and are important because of their impact on the economy, trade and food security. Highly pathogenic avian influenza (HPAI) has emerged in many countries during the last decade, but its prominence in international media and agencies overemphasises its importance in countries that are at low risk of human and animal infection.

Most Mekong countries need ongoing support from donors to control endemic diseases that are considered a social and economic burden for national and regional development. However, support from donors may not match the needs of Mekong countries for the control of livestock diseases that are considered by those countries as a major constraint for their development.

Burma's (Myanmar's) economy is predominantly based on agriculture and the majority of farmers in Burma rely on cattle and buffaloes for draught power (transportation, carrying water, ploughing etc.), so diseases affecting livestock lead to the direct and indirect loss of farmers' income and food production. During interviews with farmers on the control of FMD in Burma, one farmer commented, 'we can survive without chickens but we cannot survive without cattle because we use cattle everyday for draught power, and they provide milk, hide, meat and natural fertiliser for us'.

In Burma, the livestock diseases that are considered significant endemic diseases by the Livestock Breeding and Veterinary Department of Burma are anthrax, HS, black quarter, CSF and FMD for cattle; and Newcastle disease and infectious bursal disease for poultry (Table 1).

Zoonotic diseases of cattle and buffaloes, such as anthrax and tuberculosis, are still threatening the lives of people living in Burma who have many small and large ruminants. In the previous 2 years, there have been outbreaks of anthrax, black quarter, FMD, HPAI and HS in Burma. However, while there were many human cases of anthrax, there were no human cases of HPAI. Burma is not a rabies-free country, and although there were no officially reported cases of rabies, it is likely that the lack of cases is due to under-reporting rather than the absence of disease. Under-reporting is likely to further contribute to the disease burden of rabies as a neglected endemic disease in Burma.

The discrepancy in research and development (R&D) investment across diseases is alarming. In the last 10 years in Burma, more than US$6m has been invested in controlling HPAI, while only US$365,000 has been invested in FMD and US$2,000 has been invested in CSF. There has been no investment in important endemic diseases such as rabies, anthrax, HS, black quarter and infectious bursal disease (Table 2). This discrepancy contributes to a range of negative consequences. It is likely that the strong focus on the control of HPAI has contributed to the spread of FMD in several countries. Donor support has placed more focus on epidemic diseases, the short-term development of facilities and the provision of incentives; however, these benefits may not be sustainable without long-term funding arrangements in place. Donor support has also changed the attitudes and behaviours of stakeholders. As a consequence, the priority ranking of diseases in the Mekong region has changed and the emphasis on the control and eradication of endemic diseases has been reduced. This is

Table 1. Significant endemic diseases of livestock in Burma

Cattle	Pigs	Poultry
Anthrax Haemorrhagic septicaemia Black quarter Foot-and-mouth disease	Classical swine fever Foot-and-mouth disease	Newcastle disease Infectious bursal disease

Table 2. Summary of research and development funding in Burma, 2000–10

Disease/pathogen	Sources of funding	Total funds invested (US$)	Areas of impact
Highly pathogenic avian influenza	Australian Government Food and Agriculture Organization of the United Nations Japanese Government United States Agency for International Development (USAID) World Bank	6,331,971	Surveillance Prevention Control Diagnosis
Foot-and-mouth disease	Australian Agency for International Development (AusAID) International Atomic Energy Agency Korea International Cooperation Agency Murdoch University World Organisation for Animal Health	143,440	Surveillance Control Public awareness
Newcastle disease	Australian Centre for International Agricultural Research	117,905	Surveillance Prevention Control
Brucellosis and swine vesicular diseases	International Atomic Energy Agency	104,912	Diagnosis Control
Classical swine fever	Japan International Cooperation Agency	2,000	Surveillance

further exacerbated by decreasing interest in endemic diseases by funding organisations and researchers. A current example of changing priorities and the challenge of maintaining focus on existing endemic diseases is the spread of porcine respiratory and reproductive syndrome (PRRS) within the Mekong region. Some countries need to redirect resources to the immediate prevention and control of PRRS.

Mekong countries need to take a more balanced approach to R&D to prevent and control endemic diseases (including epidemic, trans-boundary and zoonotic diseases). This could be achieved by balancing assessment criteria for R&D including social, economic and political impacts, and the nature and epidemiology of the disease. The economic impact at farmer level needs consideration, including direct losses (illness or death of cattle) and indirect losses (loss of draught power, decreased production and cost of treatment). At the national level, the main issues to consider are trade of animals and animal products.

Donors should be asked to consider balancing investments in the prevention and control of endemic diseases (including epidemic, trans-boundary and zoonotic diseases), alongside potentially epidemic, newly emerging diseases such as HPAI.

Future R&D programs should consider the following questions:

- Are the current approaches to R&D investments striking the right balance across diseases?
- Support for many endemic diseases is still very limited—how can we change this?
- Is the primary focus on ‘pop up’ (newly emerging) diseases, in an environment where there are limited resources for disease prevention and control generally, a potential threat to the sustainable development of animal health and production?
- Can a focus on endemic diseases lead to more sustainable capacity building to prevent and control not only these diseases but also newly emerging and potentially epidemic diseases?

- How can we change the attitude of stakeholders (including investors in R&D) to develop more harmonised approaches to endemic and epidemic disease prevention and control?
- Is it possible to move from project-based investments in R&D to a more sustainable, holistic, program-investment approach?

In conclusion, it is crucial to review the R&D funding that has been invested in Mekong countries to prevent and control endemic and epidemic diseases. It is necessary to pay attention to newly emerging diseases such as HPAI; however, at the same time, existing endemic disease prevention and control should be considered for determining and prioritising future R&D funding. Investment in sustainable capacity building, with a focus on endemic and epidemic disease, is required.

Foot-and-mouth disease in the Malaysia–Thailand–Burma peninsula: addressing disease at the source

Polly Cocks, Ian Robertson, Ronello Abila, Peter Black and John Edwards

The Malaysia–Thailand–Myanmar (Burma) (MTM) zone was established in 2003 following a decision by the South-East Asia Foot-and-Mouth Disease Campaign (SEAFMD) in 2001 to establish a foot-and-mouth disease (FMD)-free zone within South-East Asia as an effective way to control FMD in the region. The MTM peninsula was selected based on favourable geographic features (Banks 2004) and strong political support from the proposed member countries.

The MTM zone comprises the southern division of Burma, regions eight and nine of Thailand and the whole of Peninsular Malaysia (see Figure 1) (Turton 2004). As a prototype for later zoning initiatives in the region, the MTM is an important component of the SEAFMD campaign. However, almost 10 years since the MTM zone was conceptualised, FMD continues to occur on a regular basis throughout much of the zone (OIE 2010).

The aim of the research reported here is to build on existing knowledge of FMD in the region by considering the epidemiology of FMD in the zone, why disease control efforts have been unsuccessful thus far, factors that threaten the success of the zone and ways in which the disease might be controlled more successfully in the future.

The MTM zone: threats and opportunities

The MTM peninsula is, by definition, surrounded by sea apart from a narrow isthmus connecting it to mainland South-East Asia. The geographical features of the region were expected to aid the control of animal movement (Banks 2004) and thus reduce the risk of FMD entering the MTM zone. However, in South-East Asia, movement of animals is largely market driven and much of the cross-border movement takes place unofficially (Gleeson 2002). Therefore, the success of controlling animal movement into the MTM zone is more dependent on prevailing market forces than on regulatory systems implemented at the zone boundary.

The market forces acting on livestock and livestock products were outlined in this study as predictors of livestock movements in the region. The results showed that the numbers of cattle and small ruminants produced within Malaysia and southern Thailand were insufficient to meet local demands, thus necessitating their importation from outside the MTM zone. Conversely, in central Burma (which lies to the north of the MTM zone), cattle and goat production is strong and supply far exceeds local demand. The MTM zone of Burma has a low demand for livestock (Naing Oo 2010) which is balanced by a low supply, therefore minimal movement of livestock into or out of this area is anticipated. The deficit of livestock within the MTM zone of Malaysia and Thailand would be expected to attract movement of cattle into the zone, while the excess of livestock in central Burma would likely lead to outward movement. The risk of FMD incursion posed by this extensive movement of livestock into the MTM zone was previously described by Wongsathapornchai et al. (2008). This research will expand upon their study to consider, in more detail, the movement patterns of livestock destined for the MTM zone with the aim of identifying potential targets for intervention measures within those pathways.

The trade pathways of livestock destined for the MTM zone were described, including the source of livestock, the stakeholders involved in livestock trade and the main pathways through which animals pass

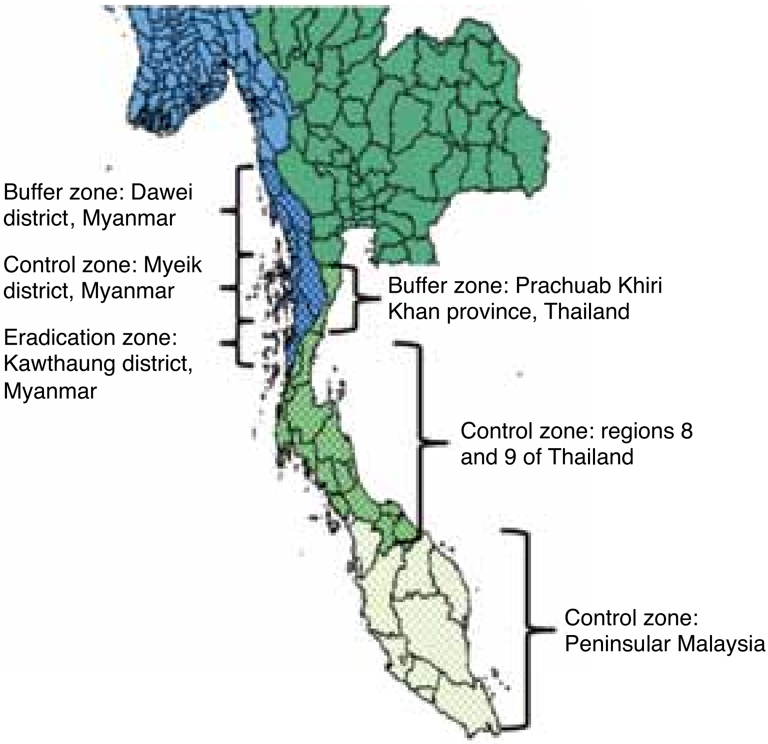

Figure 1. The geographical boundaries and zone categories of the Malaysia–Thailand–Myanmar zone

en route to the MTM zone. Results indicate that cattle and buffaloes are primarily sourced from central Burma and transit through northern and central Thailand before entering the MTM zone of Thailand and Malaysia. Cattle were also found to be moved eastwards from central Burma, through Thailand and towards Lao PDR and Cambodia. A few key trading 'hubs' were identified within Burma and Thailand, and live animal markets were identified as important components of the livestock trading routes.

The major trade pathway identified through this study was used to develop a risk simulation model to quantify the risk of FMD incursions to the MTM zone and the major contributors to that risk. The preliminary results indicate that there is a high likelihood that at least one infected animal will enter the MTM zone each week and that the prevalence of FMD in central Burma and in Thailand are major contributors to this risk The probability that infected animals fail to show clinical signs and the probability that animals enter the MTM zone unofficially are also highly positively correlated with the risk of FMD incursions into the zone (see Hawkins et al. 2012 for a comparable analysis in Cambodia).

The early results of this research highlight the importance of a regional approach to disease control, particularly in regions where there are strong drivers for livestock movement across international borders. It also emphasises the vulnerability of the MTM zone to FMD incursions through live animal movement and the importance of controlling disease at source. The potential for unofficial movement is an important consideration where countries border FMD-infected areas. Therefore, border controls aimed at preventing entry of infected animals should be balanced with the need to encourage traders to use official pathways. In conclusion, this research highlights the need to focus disease control measures at source and to look beyond the borders of the MTM zone to reduce the risk of FMD incursions into the MTM zone.

Lessons learned from the MTM zone

A salient question raised by this research is the suitability of the MTM zone as a disease control zone. The vulnerability of the zone to incursions of FMD through an influx of live animals suggests that the success of the MTM campaign is largely dependent on controlling FMD in 'upstream' areas. Further, the MTM zone has limited potential to export livestock and therefore the trade incentives for controlling the disease may be limited in this area. Future zoning initiatives would likely benefit from consideration of human and livestock demographics within the zone; drivers of livestock movement acting within, into and out of the zone; potential benefits, and benefactors, of eradicating FMD from the zone; and geographical features and political support.

Controlling cross-border movement of livestock is challenging where a zone or country shares extensive, and often porous, borders with neighbouring zones or countries. Where movement controls work in opposition to market forces, the situation is yet more challenging. Across South-East Asia, movement of livestock is largely market driven and unofficial movement of livestock is common. Therefore, the pattern of animal movement throughout the region is more a reflection of the market forces that exist than of the regulatory systems employed by each country. This study highlights the risk of FMD incursions into the MTM zone, but focuses on the whole pathway of livestock movement to identify targets for disease control measures. The purpose of this approach is to identify ways to improve preborder controls to reduce the reliance on border controls, which often have limited success. There is therefore an important trade-off between increasing regulatory measures at the border and encouraging traders to use official pathways. Biosecurity policy in the region may be better focused on preborder control of FMD and addressing disease at its source, rather than relying on excluding FMD only through increased border controls.

Controlling FMD in central Burma, identified here as a possible source of FMD, would likely have far-reaching benefits. Beneficiaries would include not only Burma, but also countries throughout South-East Asia and FMD free–countries throughout the world that are at risk from incursions of FMD. Given this range of potential benefactors, and the significant investment that would be needed to control disease in central Burma, consideration should be given to encouraging investment in the control program from those who are likely to benefit most. This is particularly relevant because the target country has limited resources with which to implement such a program. Again, this highlights the need for cooperation between countries in a regional approach to disease control in South-East Asia.

Future research and development

This research has highlighted the importance of central Burma as a potential source of FMD. Controlling FMD in central Burma would require a significant investment and, therefore, the benefits and costs of controlling FMD in this area will need to be better quantified to propose this project to potential donors. Naing Oo (2010) conducted studies in central Burma identifying FMD risk factors, animal movement patterns and some initial cost–benefit analyses of controlling FMD at the individual farmer level. This work may be expanded by analyses of costs and benefits of a large control program in the whole of central Burma, taking into account the potential impact across the region, as well as increased epidemiological studies of FMD in the region, particularly using viral sequencing to confirm sources of virus and routes of viral spread. If this research indicates that the control program is both warranted and feasible, pilot studies of control strategies may also be beneficial. A major control program in this area would require capacity building within the veterinary services for them to successfully implement such a program. This would be expected to have future benefits in controlling FMD as well as other livestock diseases in Burma.

While this study has focused on cattle and buffalo movement, the role of small ruminants in the maintenance and spread of FMD in the MTM zone and in the region continues to be neglected. Serological surveys by Naing Oo (2010) and Maung Latt (pers. comm.[1]) suggest that there is a high level of exposure of goats to FMD in central Burma, yet they are rarely implicated in FMD outbreaks in the region. Whether this is due to mild clinical signs (Kitching and Hughes 2002) and failure to recognise infected animals, or whether the animals really do play a

1 Country report of Myanmar. Paper presented at the 12th Meeting of the National Coordinators of the OIE SEAFMD Campaign, Bangkok, Thailand, 17–19 August 2009.

minor role requires further investigation. The large population of goats in central Burma (MLF 2008) and the demand for goats within Malaysia (Warr et al. 2008) suggests that movement of small ruminants from infected areas of central Burma into the MTM zone is likely.

A major challenge of this study has been the limited information available on the epidemiology of FMD in the region due to, inter alia, under-reporting of disease, limited investigation of outbreaks and limited submission of samples for serotyping and/or sequencing. During a retrospective analysis of epidemiology of FMD in the MTM zones, the value of sequencing data in understanding the spread of FMD and in identifying key foci and source areas was apparent. However, this valuable tool is still used to a limited extent in South-East Asia. A research project that aims to collect and sequence samples from outbreaks across the region would help to improve understanding of FMD in the region. It would also be useful to compare sequencing results with live animal movement pathways outlined by this and other projects in the region to determine whether the virus is, in fact, spreading through the pathways identified.

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A progressive zoning approach for the control of foot-and-mouth disease in Burma

Kyaw Naing Oo, Ian Robertson, John Edwards and Peter Black

Foot-and-mouth disease (FMD) is a highly contagious viral disease that has a significant impact on the economy and livestock productivity of affected countries. We investigated the epidemiology of FMD in a potentially free (Tanintharyi) and an endemic (Sagaing) region of Burma (Myanmar). The serological study demonstrated that the prevalence of FMD in Sagaing township was very high, with an overall seroprevalence (individual level) of 42% (95% CI 38–47). However, the prevalence varied from 22% (95% CI 3–41) to 68% (95% CI 55–81) in the studied villages. All 17 villages sampled had some positive reactors in cattle to the Cedi® FMD virus (FMDV) non-structural protein (NSP) ELISA tests and it is assumed the virus is circulating within and between the villages by a variety of means. The village-level prevalence was 100%; a village was considered infected if one or more animals were positive. The possible sources of FMD in those locations were analysed using a logistic regression model and found to be associated with communal grazing, using only underground water sources, or purchasing cattle in March annually. In contrast, FMD was negatively associated with trading of cattle within the same village where the farmers possessed less than 10 cattle.

During this study a participatory method, the Modified Traditional Dutaik (MTD) meeting approach, was developed and used as a tool for disease surveillance. This method was validated against data collected from other forms of study: testing cattle with the Cedi® FMDV NSP ELISA, conducting questionnaire interviews and obtaining expert opinions. Although the MTD meeting approach has some limitations, it is a powerful tool to detect FMD in Burma and is an appropriate technique to use in a country with significant financial constraints and a lack of adequate laboratory facilities. This approach can be used to collect data about the presence of FMD based on clinical signs that are characteristic of the disease as well as its epidemiology. A traditional Dutaik meeting approach was used previously as a tool for increasing public awareness in the Burma area of the Malaysia–Thailand–Myanmar (Burma) (MTM) FMD eradication zone. It is suggested that the modified approach (MTD) is suitable for use in progressive zoning for the control of FMD in Burma and can be used to actively involve farmers in the control program and to increase their awareness of the impact of FMD.

One of the objectives of this study was to support the Myanmar Zoning Working Group (MZWG) in establishing a progressive zoning approach. Since the 4th MZWG meeting in Mandalay in 2006, research findings from the current study have been submitted to this group. During this study, the status of the Sagaing zone has been modified—in the 2008 MZWG meeting, the total number of townships within the control zone was reduced from 15 to 13 to exclude two townships each with more than 100,000 cattle. In addition, it was proposed that the establishment of a progressive zoning approach should be combined with a vaccination program, taking into account the complex animal movements, large number of susceptible animals and the fact that FMD has been endemic for many years. Furthermore, this approach has been considered by others as an appropriate option for the control of FMD among South-East Asian countries. Expected international support for vaccine supply is likely to be limited, so reducing the number of susceptible animals in the control zone decreases the requirement for the number of vaccine doses. At this meeting, a buffer zone was proposed and established for future control of the disease. In endemic countries, the use of a coordinated vaccination program and zoning approach for the progressive control of FMD, in addition to other key factors such as control of animal movement and understanding the socioeconomic impact of the disease and prevailing serotypes, must be addressed.

A partial budgeting model with Monte Carlo simulation was developed to understand the influence of FMD on the economics of animal draught power, which is the major livestock input into national agricultural enterprises. The model revealed losses to farmers were very high if outbreaks occurred every year. The findings of this study are useful for convincing farmers of the potential losses from FMD and the financial benefit in controlling the disease.

Results

There was more movement of livestock in the Sagaing division than in the Tanintharyi division. Livestock movements in the Sagaing division were more frequent and complex because of a favourable geographical situation and the socioeconomic situation of the local people. In contrast, the Tanintharyi division is a narrow coastal area and relies heavily on transportation by water, reducing the potential for animal movement. The major direction of cattle moving in the Sagaing division was towards the larger markets in the southern part of the division and towards China in the north because of market forces. These movement data support the decision to develop a potential FMD-free zone without vaccination in the Tanintharyi division (Myanmar MTM area). Positive samples from a serosurveillance study in 2005 in the Tanintharyi division were most likely false positive results. This was supported by findings from the MTD meetings where no evidence of clinical disease was reported by farmers in contrast to areas where the disease was endemic.

After the 2005 serosurveillance program in the Myanmar MTM area, some positive serological results were found in livestock from the Myeik township. During the 2008 study, the results from MTD meetings were combined with the results from a serosurveillance study in this region to clarify the FMD situation. The study indicated that the serological results were likely to have been false positives. All findings were submitted to the MTM Tri-State Commission meeting in Malaysia in 2008, and based on this work the commission agreed to upgrade the status of each zone within the Myanmar MTM zone. This meant that the control zone progressed to an eradication zone, the buffer to a control zone and the infected zone to a buffer zone. To achieve the target of the free zone without vaccination recommended by the World Organisation for Animal Health, it is necessary to do more detailed studies in Kawthoung and Myeik districts, including putting recording processes in place to control animal movements.

Discussion

There were many time and financial constraints for this study. The Cedi® FMDV NSP ELISA test could be used only to validate the MTD meeting approach in the Sagaing and Myeik township areas. Other laboratory results were obtained from the National FMD Laboratory and serotypes associated with outbreaks were obtained from the South-East Asia Foot-and-Mouth Disease Campaign (SEAFMD) website. The field trip in the Sagaing division was conducted within a limited time frame because the accompanying staff from the Livestock Breeding and Veterinary Department had other work to do and some villages had no accommodation or electricity. As a consequence, it was not possible to collect all data and some bias may have been introduced. For example, in Ngatayaw village, the questionnaire interviews were not administered and sera were collected by convenience sampling as opposed to the random sampling that was used elsewhere. Similar constraints were encountered in the study in Myeik township because of security and accommodation difficulties. The use of a local dialect also posed challenges, resulting in the MTD meetings in Myeik being slower than those in the Sagaing division. These reflect the difficulties of conducting research in the real world.

This study has further demonstrated that FMD is an important disease of cattle in Burma and financial loss from this disease has previously been underestimated. With the current situation in the country and the existing veterinary infrastructure, the use of a zoning approach with a strategic vaccination program is suitable for the effective control of the disease. This is because FMD has been endemic within the country for many years and financial and technical constraints in controlling disease still exist. Control and eradication of the disease across the whole country is not feasible at the moment given the existing veterinary infrastructure; however, it is feasible to establish a progressive zoning approach for the control of FMD in the Myanmar MTM area without vaccination and in the Sagaing division with vaccination. The control of FMD within the country will have significant benefits not only for individual farmers, but also for the economy of the country and consequently the majority of the Burmese population.

Foot-and-mouth disease in the southern provinces of Cambodia

Tum Sothyra, Ian Robertson, John Edwards and Subhash Morzaria

Foot-and-mouth disease (FMD) is a severe, highly communicable viral disease of cloven-hoofed animals including cattle, buffaloes, pigs, sheep and goats. Although FMD does not result in high mortality in most outbreaks, the disease is debilitating and leads to significant economic losses from its impact on trade. FMD has a significant impact on livestock systems due to lower production of infected animals resulting from reduced food intake, reduced meat and milk production and draught capacity, and losses from reduced trade and tourism-related activities (Kazimi and Shan 1980; Morris et al. 2002; Perry et al. 2002).

Before this study, there was little epidemiological information on which to formulate logical procedures for control. A further constraint to the development of extension programs for the control of FMD is the lack of information about the disease, including its prevalence and incidence and the direct and indirect losses incurred. The current study was developed to better understand the pattern of FMD and the risk attributed to the spread of the disease in Cambodia. This information will be used to underpin the establishment of a progressive zoning approach to control FMD in the Lower Mekong Basin (LMB).

Materials and methods

Study site T

The study was conducted in eight southern provinces of Cambodia: Kampong Speu, Kampot, Kandal, Koh Kong, Phnom Penh, Prey Veng, Sihanouk Ville and Takeo. These sites were initially identified by the South-East Asia Foot-and-Mouth Disease Campaign (SEAFMD) Program as suitable for developing a zone for the control and eradication of FMD in the LMB.

Sampling design

A two-stage sampling technique was used for selecting the study sites. Survey Toolbox (Cameron 1999), using an expected prevalence of 20%, and a between and within village variance of 0.05 and 0.2, respectively, was used to determine the number of villages and animals to sample. This program determined that 70 villages with 14 animals per village needed to be sampled.

A total of 490 farmers from 70 villages were interviewed. During the blood sampling, seven farmers were randomly selected from each village for questioning.

Questionnaire preparation

The questionnaire covered many aspects of livestock management including species of livestock kept, types of grazing, feeding, watering, possible contact between herds and disease management. After being pre-trialled and revised, the questionnaire was administered.

Laboratory analysis

Two enzyme-linked immunosorbent assays (ELISA)—non-structural protein (NSP) and liquid-phase blocking (LPB)—were used. These tests are serotype-specific and are highly sensitive, and the virus or antigen used in the test is closely matched to the strain circulating in the field (OIE 2008). Both NSP and LPB ELISA kits and techniques were developed by the regional reference laboratory for FMD, Pakchong, Thailand.

Statistical analysis

The seroprevalence was calculated for the NSP ELISA, and the mean antibody titre and type of FMD virus (FMDV) were calculated for the LPB ELISA. A village was considered to be positive if one or more of the sampled animals were seropositive (Bronsvoort et al. 2006). The exact binomial approach was used to calculate the 95% confidence intervals (CI) for the prevalence (Daly 1992).

The relationship between prevalence and age and gender was investigated using linear regression. The association between age and positivity was assessed by using ANOVA and Kruskal-Wallis tests, while a Chi-square test for independence and odd ratios and their 95% confidence intervals were calculated for gender (Armittage and Berry 1987; Martin et al. 1987). The prevalence was also stratified by the age of animals (Bronsvoort et al. 2006).

Putative risk factors for infection and causes of disease spread were analysed using Pearson's correlation coefficient and logistic regression techniques. Univariate analyses were used to identify any potential risk factors associated with infection by applying a chi-squared test for independence, a Fishers exact test for categorical variables or an ANOVA for continuous variables. Then multivariable analyses were conducted where variables with a P value ≤ 0.25 in the univariate analyses were offered to a logistic regression model using a backward stepwise conditional method (Hosmer and Lemeshow 1989; Frankena and Graat 1997).

Results

Prevalence estimation

The results for the LPB and NSP ELISAs are summarised in Table 1. A total of 277 animals sampled (30%, CI 27.1–33.0%) were seropositive for FMD. The village-level prevalence of FMD in the southern provinces of Cambodia was 87% (CI 79.0–94.9%). There was a significant difference in the distribution of seroprevalence between the different provinces ($\chi^2(1, 7) = 41.027$, $P = 0.000$).

Three FMDV serotypes were present in the southern provinces of Cambodia with a prevalence of 28.5% (CI 25.6–31.5%) for type O, 9.5% (CI 7.7–11.6%) for type A and 9.3% (CI 7.5–11.4%) for type Asia 1. In general, the seropositive animals had low antibody titres to FMDV serotypes A and Asia 1. In contrast, titres to type O were up to 1:5120. Serotype O was present in most villages sampled (84.1%, 58 of 69) followed by type Asia 1 with 59.4% (41 of 69) and type A with 50.7% (35 of 69).

There was no significant difference in the prevalence of FMD in males (20.7%) and females (28.8%) ($\chi^2(1,1) = 2.503$, $P = 1.114$). However, the prevalence between the age groups ($\chi^2(1,10) = 22.544$, $P = 0.013$) was significantly different. The prevalence generally increased with age from 16.7% in the 1-year-old group to 50.0% in the 10-year-old group of animals.

Animals were regrouped into young (up to 2 years old) and adult (more than 2 years old) groups comprised of 209 and 551 individual animals

Table 1. The results of the LPB and NSP ELISA from different Cambodian provinces

Province	Samples	LPB ELISA				NSP ELISA			
		Positive	Prevalence (%)	CI lower (95%)	CI upper (95%)	Positive	Prevalence (%)	CI lower (95%)	CI upper (95%)
Kampong Speu	191	111	58.1	51.1	65.1	67	35.1	28.3	41.8
Kampot	154	81	52.6	44.7	60.5	55	35.7	28.1	43.3
Kandal	135	55	40.7	32.5	49.0	28	20.7	13.9	27.6
Koh Kong	14	6	42.9	16.9	68.8	0	0.0	0.0	0.0
Phnom Penh	14	9	64.3	39.2	89.4	7	50.0	23.8	76.2
Prey Veng	207	106	51.2	44.4	58.0	52	25.1	19.2	31.0
Sihanouk Ville	28	25	89.3	77.8	100.0	19	67.9	50.6	85.2
Takeo	180	109	60.6	53.4	67.7	49	27.2	20.7	33.7
Overall	923	502	54.4	51.2	57.6	277	30.0	27.1	33.0

CI = confidence interval; ELISA = enzyme-linked immunosorbent assay; LPB = liquid-phase blocking; NSP = non-structural protein respectively. The seroprevalence in adults was significantly higher (32.3%) than in young animals (21.1%), ($\chi^2(1,1) = 9.278$, $P = 0.002$). The antibody level in the adult group was also higher than for the young group. There was a significant difference between seroprevalence in adults and young animals for serotype O ($\chi^2(1,1) = 26.618$, $P = 0.000$) but not for serotypes A ($\chi^2(1,1) = 2.440$, $P = 0.118$) or Asia 1 ($\chi^2(1,1) = 2.455$, $P = 0.117$).

Determinants of FMD

The logistic regression model statistics are summarised in Table 2. The results from this analysis revealed that villages where farmers sought assistance from the village animal health worker were 2.8 times more likely to have FMD than in villages where no animal health services were provided. Animals that shared common grazing areas were 2.5 times more likely to contract FMD than those not grazing in common pastures. Similarly, villages where infected cattle were sold were 2.3 times more likely to have FMD than those that didn't sell infected cattle. Pigs raised under free-range conditions were 1.9 times more likely to result in FMD than those that were penned or tethered. Interestingly, farmers who vaccinated against FMD were 3.9 times more likely to report outbreaks than those who did not vaccinate their animals. Animals that were tethered and fed cut grasses were less likely to get infected with FMD.

Discussion

The results from this survey indicated that FMD is endemic in the southern provinces of Cambodia and three FMDV serotypes (type O, A and Asia 1) are responsible for outbreaks in this region. Although these serotypes are widely distributed in the southern provinces of Cambodia, the high seroprevalence of antibodies to type O in animals of all age groups and in most villages indicate that this serotype was responsible for the most recent outbreaks. In contrast, the animal-level and age-stratified seroprevalence for type A and the distribution in the villages sampled suggested that few cattle had been exposed to this serotype. The lower seroprevalence in younger animals may be due to lower opportunities for exposure to FMDV. The presence of this serotype in Cambodia may suggest that FMDV type A is circulating in cattle and buffaloes and may cause outbreaks.

The age-stratified seroprevalence and distribution of type Asia 1 in seropositive villages suggest that there has been less recent exposure to type Asia 1 virus, as none of the sampled animals were seropositive to only serotype Asia 1. If the type Asia 1 virus was not circulating widely—boosting animal and herd immunity—the antibody titres would be expected to be lower in younger animals. The small proportion of samples within villages that were positive and a low age-related seroprevalence can be explained by a combination of waning antibodies, and a decreasing number of older seropositive animals. It is possible that, similar to other countries in the region, serotype Asia 1 may become extinct locally, leaving a highly susceptible population. The low antibody titre detected to FMDV type Asia 1 may reflect the absence of this serotype in recent years, which was last reported in Cambodia in 1997 (Gleeson 2002). Moreover, since the viral properties of FMDV serotype O and Asia 1 have a relatively high homogeneity, the low level of antibody to serotype Asia 1 may have resulted from

Table 2. Results of a multivariable logistic regression analysis of risk factors for foot-and-mouth disease in southern Cambodia

Risk factors	β	Association with FMD			*P*
		OR	95% CI for OR		
			Lower	Upper	
Constant	–1.9	0.1			0.000
Shared grazing areas	0.9	2.5	1.6	3.8	0.000
Intervened by village animal health worker	1.0	2.8	1.6	4.9	0.000
Fed cattle cut grasses	–1.9	0.2	0.1	0.5	0.001
Sold infected cattle	0.9	2.3	1.4	3.8	0.001
Vaccination against FMD	1.4	3.9	1.6	9.6	0.003
Kept free-range pigs	0.7	1.9	1.2	3.1	0.006

CI = confidence interval; FMD = foot-and-mouth disease; OR = odds ratio cross reaction on the ELISA test (Lu et al. 2008). The outbreak of FMD in 2006 in Cambodia may confirm this assumption as only serotypes O (Pan-Asia strain) and A were involved.

The current study also revealed that movement of people and infected animals during the outbreaks, sharing of common grazing land, raising pigs under free-range conditions and vaccination against FMD posed a significant risk to the dissemination of FMDV in the southern provinces of Cambodia. However, movement of animals is probably the most important factor contributing to the spread of FMD (Rweyemamu 1984; Ferris et al. 1992; Perry et al. 2002). Numerous authors have highlighted that the outbreaks of FMD were associated with livestock and livestock products movement (Aidaros 2002; Leforban and Gerbier 2002; More 2002; Bouma et al. 2003; Gloster et al. 2003; Knowles and Samuel 2003). It is possible that lack of biosecurity, poor reinforcement of legislation on movement restrictions in infected areas by the government veterinary authority during outbreaks, and a lack of established on-road checkpoints may contribute to the dissemination of FMDV. Movement of infectious animals that are in a contagious state is known to increase the risk of introducing disease to healthy flocks by both direct or indirect contact arising from mixing (Christley et al. 2005). Since airborne spread has almost no influence on the transmission of FMD in the tropics, distance of possible spread and the size of the epidemic depend very much on direct contact between infected and susceptible animals (Thomson 1995; Sutmoller et al. 2000; Alexandersen and Mowat 2005). Movement of people also revealed a significant level of risk in the spread of disease (Laryea 1975; Rweyemamu 1984).

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