

**The History of Koi Aquaculture in Singapore from
1965 to the Present: Translating Translocated
Scientific Knowledge from Japan into Biosecurity**

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Summary

Koi is a non-native ornamental commercially valuable species imported and cultivated as an ornamental fish in Singapore. In this thesis, I analysed the translocation of Japanese koi to Singapore from 1965 to 2018. In order to successfully translocate koi from Japan to Singapore, its environment had to be translated into scientific and vernacular knowledge which were translated into Singapore farm practices, policies and regulations by different social groups. Singaporean hobbyists attribute many of the differences among the koi kept in Japan versus that of in Singapore to the difference in climate and environment, in particular different water conditions. My study was an attempt to answer these questions: First, how and why did ornamental aquaculture practices in Singapore change over time? Second, what did Singapore take from Japan's koi cultivation practices, and how did they change them? Finally, what kind of knowledge is derived from koi aquaculture? I answered these questions by analysing the kind of knowledge that emerged from the translocation of koi and the translation of this knowledge into Singapore farm practices, government policy and regulations.

I conducted semi-structured interviews and participant observation, and used snowball sampling to obtain interviewees, between June 2015 to the end of 2016 in both Singapore and Niigata Prefecture, Japan. I used document sources to build a qualitative history

of the ornamental aquaculture industry of Singapore. I analysed the kinds of knowledge generated by the people working within agriculture, prioritizing ornamental fish aquaculture. I used thematic analysis to code my data and obtain themes. Two main themes emerged: the importance of water and the biosecurity of koi aquaculture in Singapore from the analytic lenses translation and translocation.

Biosecurity emerged from the translocation and translation of koi and KHV from Japan to Singapore. Knowledge about KHV was translated into a disease-regulation protocol in Japan. The protocol was then transferred to Singapore and officials used a militarized concept of disease to translate the protocol into biosecurity regulations. This facilitated the formation of new koi-cultivation practices in the form of strict quarantine and certification measures that impacted farm practices and eventually the ornamental fish aquaculture industry in general. The biosecurity measures prioritized disease-free status of koi in Singapore. The implementation of these strict measures fell to the regulatory officials of the AVA, and thus contributed not only to the more antagonistic relationship between the regulators and the regulated, but also to the decline of the koi industry in Singapore. The translocation of koi from Japan to Singapore provided the impetus for scientific knowledge generation about koi and its complex relationships. The translations of this knowledge into a disease management protocol that could be understood and implemented resulted in the emergence of

biosecurity within ornamental fish aquaculture.

Acronyms and Vocabulary

AVA: Agri-food and Veterinary Authority of Singapore, was the PPD until 2000.

HDB: Housing Development Board of Singapore.

INPC: International Nishikigoi Promotion Center, based in Niigata, Japan.

JNPA: All Japan Nishikigoi Promotion Association. The JNPA is an association of Nishikigoi breeders and dealers with approximately 650 members worldwide. JNPA certifies all koi judges for koi shows.

KHV: Koi Herpes Virus. A virus that was first discovered in 1999, was named in 2000 and became prominent in Singapore in 2006.

Koi: A fish known variously as ornamental carp, coloured carp, fancy carp, nishikigoi (錦鯉), irogoi (色鯉). Its species name is *Cyprinus carpio*, and actually is the same species as common carp. Common carp is bred to be eaten, koi is not.

PPD: Primary Production Department of Singapore. It was renamed the AVA in 2000.

PUB: Public Utilities Board of Singapore

Chapter 1: Introduction

1.1 Introduction to Koi Aquaculture in Singapore

Ornamental fish aquaculture tends to be practiced inland. Within Singapore, most ornamental fish are tropical freshwater fish, and tropical fish has been used interchangeably with ornamental fish, particularly by both hobbyists and farmers of ornamental fish, and all ornamental fish in Singapore's farms are farmed inland. Inland farming of freshwater ornamental fish resulted in contemporary tension over the use of limited land and freshwater for ornamental fish.

Water as a medium and environment in aquaculture includes factors such as oxygen levels that have to be considered and controlled by the farmers. These factors are also called water parameters, which are chemical, biological, physical and radiological characteristics of a particular sample of water.¹ Land-based freshwater farmers have near total control over most of the water factors and quality on the farm, while in marine aquaculture control over water quality and flow can vary based on the structures and type of farming.

From the 1970 to the 1990s, Singapore's ornamental fish industry had grown large enough to warrant special government investment and attention, particularly from the Primary Production Department, which had been an amalgamation of the agriculture, co-operatives, fisheries,

¹ Donald L. Johnson et al., 'Meanings of Environmental Terms', *Journal of Environmental Quality* 26, no. 3 (1997): 581-589.

rural development and veterinary divisions of Singapore's Ministry of National Development in 1959. The history of demand for ornamental fish started in the late nineteenth century² but it still very much has contemporary effects. This history of the ornamental fish trade in Singapore is not only extremely contemporary, stretching back earlier than Singapore's Independence in 1965, but also stretches forward to the present day. How did the ornamental fish industry develop in Singapore in a time when newly-independent Singapore was searching for that identity in a world still dealing with the after effects of colonialism? This had happened despite the competing issues of limited land and water in Singapore, with Singapore's ornamental fish trade becoming the top global exporter of ornamental fish in the 1990s to 2003.³ What had triggered the decline of the industry, which officials had consistently announced as having huge potential for growth?

Examining the ornamental fish industry is not an easy endeavour as there are many kinds of fish species involved, each with their unique requirements and own market. One of the most ostentatious and obvious freshwater ornamental fish in Singapore, however, is the koi, also known as ornamental carp or the current Japanese term, *nishikigoi*.

Koi initially was bred from common carp for food in China, but the brilliantly multi-coloured forms that we find frequently in ponds as

² Rehbock, "The Victorian Aquarium," 522-39; Bernd Brunner, *The Ocean at Home: An Illustrated History of the Aquarium*. New York: Princeton Architectural Press, 2005, 38-58.

³ "New business cluster to boost ornamental fish trade", in *AVA Vision*, December 2003, 10

pets and decoration worldwide and call koi was bred in Japan. The form of what we now categorize as koi has been agreed to be bred primarily in the Niigata Prefecture, initially for food, but after the first appearances of koi that were slightly blue roughly two hundred years ago, farmers started rearing them for ornamental purposes. Today, the majority of high quality koi breeds are from Niigata Prefecture, and koi is considered Niigata's prefecture specialty product, much like Niigata's rice. Therefore, when examining koi in the Japanese context, even in relation to Singapore, my examination is mainly in context with Niigata Prefecture, rather than the rest of Japan since the rest of Japan has very little to do with koi aquaculture.

While in contemporary times koi might be imported from other countries such as China, and many other countries are also breeding koi, the highest quality and new breeds still are considered by hobbyists and farmers alike to primarily originate from Niigata Prefecture. Hence a historical analysis of koi as an ornamental fish species in Singapore has to not only consider the relationship between Japan and Singapore, but Niigata in particular. The movement of koi from Japan to Singapore is transnational, but also occurred in historical and social contexts. These contexts determined the kind of knowledge that was transferred, and how it was translated into aquaculture practice in Singapore. The transference of knowledge along with the koi and the translation of this

knowledge into aquaculture resulted in the translocation of koi and its knowledge.

Before analysing ornamental fish aquaculture in Singapore, I have to elaborate on several bodies of literature, in how animals and humans interact. These include how animals are used to reflect human traits in exhibition of animals, companion animals, and as model animal systems. Then I can discuss ornamental fish in the context of aquaculture, particularly how information and knowledge is obtained and researched.

1.2 Human and Animal relationships

The history of koi as an ornamental fish places koi within several bodies of literature. Animals have had links to humans in a diversity of ways. In order to think critically about the relationship koi has with humans, I have to consider the kinds of relationships animals generally have with humans in the literature. In particular, the transnational nature of koi is an important factor in the analysis of koi and its relationships. In this thesis, movement of koi is important, not just the physical movement, but the movements of koi and the systems and the knowledge that was moved along with it. Motivations of people in translocating koi was important to the translating of the koi's relationships and systems into practices, which meant that the human relationship was vitally important in situating my analysis of koi.

Breeding animals was linked to social aspects has been used in

various analyses, such as linking animals to social class and gender,⁴ and a nation's economy.⁵ Particular animal breeds have also been linked to nationality⁶ or particular national traits that are desirable.⁷ The linking of ornamental fish to Singapore's reputation falls within this framework. Ornamental fish have the unique feature of occupying several categories of animals – being that they are treated as pets and not consumed, but also the breeding of fish is dependent on the aquaculture industry, in which the development of breeding and management techniques fall under the industrial category of agriculture. Small ornamental fish such as guppies and goldfish were routinely used as representing other species of fish for scientific purposes, and koi are the same species as the common carp, and are treated differently by farmers.

Animals have been used for various purposes, by using them as displays of imperial power,⁸ and as symbols of nationhood. Displaying exotic animals such as tropical fish from far off colonies in the early twentieth century was not only a marvel of technological advancement

⁴ Martin Johnes, "Pigeon Racing and Working-Class Culture in Britain, C. 1870-1950," *Cultural and Social History* 4, no. 3 (2007): 361-83.

⁵ Daryl Leeworthy, "A Diversion from the New Leisure: Greyhound Racing, Working-Class Culture, and the Politics of Unemployment in Inter-War South Wales," *Sport in History* 32, no. 1 (March 2012): 53-73.

⁶ Harriet Ritvo, "Pride and Pedigree: The Evolution of the Victorian Dog Fancy," *Victorian Studies* 29, no. 2 (1986): 227-53; Phillip Howell, "The Dog Fancy at War: Breeds, Breeding, and Britishness, 1914-1918," *Society & Animals* 21, no. 6 (2013): 546 - 567.

⁷ Rachel Carr, "100% Pure Pigs: New Zealand and the Cultivation of Pure Auckland Island Pigs for Xenotransplantation," *Animal Studies Journal* 5, no. 2 (2016): 78-100.

⁸ Sofie Lachapelle and Heena Mistry, "From the Waters of the Empire to the Tanks of Paris: The Creation and Early Years of the Aquarium Tropical, Palais de La Porte Dorée," *Journal of the History of Biology* 47, no. 1 (1 February 2014): 1-27.

in aquaculture, but also a way to present animals as representatives of faraway colonies, "inspire a sense of adventure and discovery in visitors" but also to "instill pride."⁹ The display of the animals in the colonial era aquariums were carefully exhibited in as close a fashion to "natural habitats" of the individual colony,¹⁰ which linked the animals to their native habitats and celebrated the fact that they were colonial subjects of the viewers. Animals in exhibition were generally focused on how animals were used to reflect the viewers' own characteristics, be that nationalistic pride or other virtues. While exhibited in events such as koi shows, koi also interact often with their owners, and their relationship with humans extend beyond a reflection of human traits.

The linking of the bulldog to English nationality was "carefully nurtured and publicized"¹¹ by various animal societies in England in order to associate the bulldog's courage to English-ness.¹² Nationalistic qualities of animals, particularly pets, were strongly influenced under states of pressure. The dachshund, for example, declined in popularity in Britain during World War I because of its association with the "alien"¹³ German trait. British dog breeds were defended in the time of war austerity because they were British and that "patriotism and

⁹ Lachapelle and Mistry, "From the Waters of the Empire to the Tanks of Paris," p11.

¹⁰ Ibid.

¹¹ Ritvo, "Pride and Pedigree", p227.

¹² Ritvo, "Pride and Pedigree", p250.

¹³ Phillip Howell, "The Dog Fancy at War: Breeds, Breeding, and Britishness, 1914-1918," *Society & Animals* 21, no. 6 (2013): 546.

breeding of dogs were synonymous."¹⁴

In addition to being exhibition animals, koi is a companion animal that people keep and form emotional connections with them. In companion animal literature, the animal and human relationship are portrayed as reciprocal. Authors such as Donna Haraway's work on primates centers gender and viewership in primate-human studies,¹⁵ and then how companion animals and humans meet in reciprocal relationships.¹⁶ Katherine Grier's work on pets in America and how pets foster caring emotions in humans.¹⁷ This body of literature tends to focus only on human and animal in a domestic space, while in my project I am also considering koi outside of the domestic spaces.

As a domesticated animal, koi's breeding is heavily manipulated by humans. Manipulation and control of breeding animals and other organisms have also been fruitful in producing scientific ideas. The breeding of fancy pigeons, for example, helped Charles Darwin formulate the Theory of Natural Selection.¹⁸ Such manipulation also allowed for specific breeds of animals to be reconceived as a national breed, such as the English bulldog in the nineteenth century. Animal breeding also shed light on the understanding of how heredity and

¹⁴ Howell, "The Dog Fancy at War," 559.

¹⁵ Donna Jeanne Haraway, *Primate Visions: Gender, Race, and Nature in the World of Modern Science* (Psychology Press, 1989).

¹⁶ I. Donna Jeanne Haraway, *When Species Meet*, (Minneapolis: University of Minnesota Press, 2008), 95-132.

¹⁷ Katherine C. Grier, *Pets in America: A History* (UNC Press Books, 2006), 127-181.

¹⁸ James A. Secord, "Nature's Fancy: Charles Darwin and the Breeding of Pigeons," *Isis*, 1981, 163-186.

society could collide, with society influencing the definition of heredity as "understood through the effects of purebred breeding,"¹⁹ and genetic cloning of animals remade human understanding of genealogy and genetics.²⁰ The usage of animals were mainly to understand of life and ultimately aimed at providing more understanding human life.

Fish, specifically, were useful animals for display, study and companionship. Since people were normally unable to view them from the land, the development of specific technologies such as aquariums were necessary. Aquarium and water circulatory technologies were started from the 1800s,²¹ with ornamental fish having a long history entwined in both scientific discovery and human interest in the aquatic world, a world so different from our terrestrial one that the animals and plants living underwater look almost alien. The fascination with the underwater world has been traced back to Victorian Europe,²² and the eventual development of what might be considered the modern aquarium to investigate various aspects of social histories and developments of countries in the 1880s in Europe. English freshwater fish, for example, held little to no particular fascination to the Victorian Englishman, because these were common and part of their everyday lives as children and adults. Bernd Brunner argued that as the

¹⁹ Margaret Elsinor Derry, *Horses in Society: A Story of Animal Breeding and Marketing, 1800-1920* (Toronto; Buffalo: University of Toronto Press, 2006), 234.

²⁰ Sarah Franklin, *Dolly Mixtures: The Remaking of Genealogy* (Duke University Press, 2007).

²¹ Brunner, *The Ocean at Home*.

²² Philip F. Rehbock, "The Victorian Aquarium in Ecological and Social Perspective," in *Oceanography: The Past* (Springer, New York, NY, 1980), 522-39.

development of the railroads in Great Britain, then the rest of continental Europe and parts of the USA increased, easy public access to the ocean and the vastly different aspect of the aquatic life there changed the public imagining of the aquatic,²³ which in turn led to the huge popularity of public aquariums and finally to private home aquariums.

The taste for the new and exotic had an extra dimension especially in the colonialism of the time. Exposure to exotic fish species not only led to national pride,²⁴ it also encouraged a demand to possess and display the novel species. Demand for novelty was voracious, which meant that for the most part, European temperate wild-life was dull and familiar. Tropical fish, however, was vastly in much higher demand because they were colourful and unfamiliar, and soon the term "tropical" came to be synonymous with colourful and in particular, ornamental. While koi was not tropical, it had the advantage of being larger and more colourful than the somewhat commonplace goldfish.

Impressive and large displays of colourful ornamental fish necessitated the advances into material sciences. Materials that could withstand the pressure of large volumes of water, the corrosive properties of water (particularly of seawater), and yet allow a view to the inside of the tank were one of the important aspects that came out of

²³ Brunner, *The Ocean at Home*, 10.

²⁴ Lachapelle and Mistry, "From the Waters of the Empire to the Tanks of Paris," 11.

this development.²⁵ More importantly, however, was the knowledge involved in trying to sustain the living fish within the water. The motivations of the scientist and the fish-owner were thus turned to investigate quality of the fish's environment.

1.3 Aquaculture and science

The association of aquaculture with science also has a long history.²⁶ As I had mentioned earlier, animals had been used to generate knowledge, particularly about humans. Aquatic animals and by extension aquaculture had a long association with naturalists dating back to the 18th century. The naturalists' motivations in studying aquaria and aquaculture had a history. Initially the aquarium was associated as a derivation of Victorian hobbyists who collected plants and animals in display vessels,²⁷ developing into the vessels to hold and observe aquatic life.²⁸ Eventually the goal of a nineteenth century "true aquarium" was to "remain in a healthy state for months or even years, without requiring any renewal of the fresh or saltwater medium."²⁹ Naturalists of the nineteenth century tried to study ways to develop miniaturized aquatic ecologies which were self-sustaining. They had to develop a framework around the ecology that they were trying to create, and discern factors that they were able to manipulate in order to achieve

²⁵ Lachapelle and Mistry, "From the Waters of the Empire to the Tanks of Paris," 8.

²⁶ Brunner, *The Ocean at Home*.

²⁷ Brunner, *The Ocean at Home*, 20.

²⁸ Philip F. Rehbock, "The Victorian Aquarium in Ecological and Social Perspective," in *Oceanography: The Past* (Springer, New York, NY, 1980), 522-39.

²⁹ Rehbock, "The Victorian Aquarium," 523.

this goal. The first attempts were by varying the inhabitants of the aquarium to maintain this elusive balance. But when fish were chosen for aesthetic purposes rather than for sustainability, the goal in aquariums was to change water quality such as developing aerators.³⁰ When the goal of aquariums were to be large and long-term but still containing specific animals, then the need to manipulate the environment within the aquarium became critical. This manipulation comes under the purview of aquaculture, which is when humans attempt to rear and breed specific aquatic animals in captivity for food or ornamental purposes.

Aquaculture has several features. Thanks to the medium, water, aquaculture can be boundary-less, depending on whether it is conducted inland or not. Water also additionally has an added dimension of water-depth, allowing for animal stocking density to be considered per unit volume rather than per unit area. Coupled with the fact that there is a high proportion of coastline to inland,³¹ the exploitation of aquatic resources can be very attractive and "provide densely populated areas where meat is a luxury with a cheap source of protein."³² The answer to how to feed a China with a rapidly growing

³⁰ Rehbock, "The Victorian Aquarium," 534.

³¹ P. Boomgaard, "In a State of Flux: Water as a deadly and a life-giving force in Southeast Asia," in *A World of Water: Rain, Rivers and Seas in Southeast Asian Histories*, edited by P. Boomgaard, Verhandelingen van Het Koninklijk Instituut Voor Taal-, Land- En Volkenkunde 240 (Leiden: KITLV Press, 2007), 8.

³² Ibid.

population, for example, could be answered with intense aquaculture.³³ Much of the current research on aquaculture focuses on food aquaculture, predominantly on marine aquaculture. The coastal areas might be "naturally and socially marginal spaces in that they serve as the limit between sea and land,"³⁴ and hence are interesting to study because they are socially fraught. This does not however capture the issue on inland aquaculture, where the land spaces are not only in competition with other terrestrial issues such as housing, city infrastructure or even terrestrial agriculture, but also have special requirements such as access to large good quality water-sources. This is particularly important in ornamental fish aquaculture, as most ornamental fish are cultivated inland, such as in Singapore. In order to deal with this restriction, inland aquaculture has turned to water-recycling and reusing of water, to conserve water volume. Water quality itself became a huge issue. In fact, how is good quality water even defined, obtained and maintained? How is this information about water understood and then applied to aquaculture? These questions were large enough that I have felt that it was necessary to dedicate the next chapter (Chapter 2) to the analysis of water, water quality and how it shaped the ornamental fish industry in Singapore

³³ Barbara J. Culliton, "Aquaculture: Appropriate Technology in China," *Science* (New York, NY) 206, no. 4418 (1979): 539.

³⁴ John Kleinen, "Stealing from the Gods," *A History of Natural Resources in Asia*, 2007, 245.

1.4 Koi and its Aquaculture in Singapore

The history koi aquaculture in Singapore developed against the context of Singapore's aquaculture industry in general, and ornamental fish industry in particular. As a result, the knowledge required to keep koi and other ornamental fish alive had to be generated somehow – knowledge about aquatic animals and systems had to be made legible and useful for human owners to apply to keeping koi alive. As koi are kept mainly for ornamental purposes, rather than for food, they can be classified as pets. Human owners of koi also developed emotional relationships with their koi as humans do with conventional companion animals.³⁵ As I had mentioned earlier, pets in particular have historically been associated with nationhood, be it in particular traits they are assumed to have displayed³⁶ or embodied.³⁷ Animals can also be used to indicate social statuses and other such aspirations.³⁸ As such, koi in Singapore also could be indicators of similar class issues, since if someone wanted to keep koi they would have to be able to afford the land to have a pond. More interestingly, however, is the fact that koi has a unique status of being Japanese – much like how the dachshund is associated with being German in wartime Britain,³⁹ and is constantly being brought into Singapore, rather than being bred and naturalised

³⁵ Grier, *Pets in America*, 130.

³⁶ Ritvo, "Pride and Pedigree," 250.

³⁷ Phillip Howell, "The Dog Fancy at War," 547.

³⁸ Ritvo, "Pride and Pedigree," 255.

³⁹ Phillip Howell, "The Dog Fancy at War," 546.

into the Singaporean landscape. This opens up the koi aquaculture in Singapore to being part of a transnational system, rather than a closed localized system. Animals such as livestock⁴⁰ can be considered in a more closed system, and pets like dogs and pigeons⁴¹ can and were bred locally. Koi in Singapore, on the other hand, shares characteristics with exotic pets of the eighteenth century Europe⁴² because they are not considered local; koi hobbyists do not consider koi bred in Singapore as on par with those imported directly from Japan, emphasizing their transnational nature.

Since Japanese koi is constantly imported into Singapore, then the need to keep these koi alive and in a condition for sale is vital. So while there is a lot less focus on breeding in Singapore's koi aquaculture than most other animal fancy, other aspects of the koi industry rise in relative importance. Maintaining and obtaining koi in sale worthy condition thus dominates the koi aquaculture industry. The science and history of koi aquaculture in Singapore reflects this by focusing on generating knowledge of the koi and its environment in order to allow humans to understand and manipulate this environment.

Even while the identity of the koi itself is maintained as Japanese and non-local, the ornamental fish aquaculture industry had somehow become tied into Singapore's identity (elaborated in Chapters 3 and 5),

⁴⁰ Margaret E. Derry, *Masterminding Nature: The Breeding of Animals, 1750-2010* (Toronto: University of Toronto Press, 2015).

⁴¹ Secord, "Charles Darwin and the Breeding of Pigeons," 163-86.

⁴² Louise E. Robbins, *Elephant Slaves and Pampered Parrots: Exotic Animals in Eighteenth-Century Paris* (Baltimore: JHU Press, 2002).

as the Singapore started to act as a middle-man in the importing and exporting of ornamental fish, koi being one of the largest draws in the industry. As koi are constantly imported into Singapore, translocation becomes key to the analysis of how people within the Singapore's aquaculture industry attempt to adjust and translate temperate climate husbandry practices and the koi's environment in Japan into practices to maintain koi in a tropical climate.

The transnational nature of the koi aquaculture industry in Singapore also opens up the industry to the movement of not just koi, but of other organisms and quantities. As historian Nicholas King had written of people, "The very postmodern networks that allow them to exercise control over the modern global economy and their own bodies also render them vulnerable to the most primitive microscopic pathogens."⁴³ The global network that allowed koi to be transported from Japan to Singapore and out to other countries opened Singapore's ornamental industry to vulnerability, particularly in the form of microorganisms and other such invisible agents. The scientific knowledge associated with aquaculture not only has to be used to maintain the koi in Singapore, but also in an attempt to understand the invisible pathogens that infect the aquaculture network, and subsequently the koi in Singapore.

⁴³ Nicholas B. King, "Networks, Disease, and the Utopian Impulse," in *Networked Disease*, ed. S. Harris Ali and Roger Keil (Wiley-Blackwell, 2008), 202.

1.4.1 The Generation of Scientific Knowledge in Aquaculture

Much of the contemporary knowledge involved with aquaculture and disease is generated as scientific knowledge before subsequently being translated into other forms of knowledge and practice. In the previous section I had started to describe certain actions taken in the generation of scientific knowledge in order to visualise disease-agents for the enactment of biosecurity. Such scientific knowledge has to be contextualised in a historical context in order to make sense of the knowledge being generated and how the society around it interacts, transmits and mediates the use of this knowledge. The sociological milieu that surrounds the production of what we consider scientific knowledge is important in the production and making of modern science.⁴⁴ Ideas and concepts of science appear to the outsider, and even to many scientists, as impartial and apolitical. However the production of scientific knowledge is anything but apolitical, as political and sociological pressures shape the acceptance of scientific theories, and even social and political pressures can elevate one theory over another.⁴⁵ One idea in science studies is that of "technological determinism", that is, the idea that technologies "change, either because of scientific advance or following a logic of their own; and they then have effects on

⁴⁴ Bruno Latour and Steve Woolgar, *Laboratory Life: The Construction of Scientific Facts* (Princeton University Press, 2013).

⁴⁵ Simon Schaffer and Steven Shapin, "Leviathan and the Air Pump," Hobbes, Boyle, and the, 1985.

society,"⁴⁶ a view of technology that is a common portrayal in the popular imaginings and media of technology. It is true that technology matters to our sociological lives. Historians can attribute particular developments of society to technological inventions, for example, Lynn White's work in attributing the development of feudal society to the invention, and subsequent spread to Western Europe, of the horse stirrup. MacKenzie and Wajcman criticize this idea as somewhat too simplistic, and consider that there are a set of social conditions required to build such a society, for example, instead of solely military technology. They are, in fact, making a similar argument that Shapin and Schaffer had in *Leviathan*. Shapin and Schaffer had used the example of Robert Boyle's air-pump to characterise "historical circumstances in which experiment as a systematic means of generating natural knowledge arose, in which experimental practices became institutionalized, and in which experimentally produced matters of fact were made into the foundations of what counted as proper scientific knowledge,"⁴⁷ and by looking at the paradigms of science. The prevailing idea is that science and technology has an influence on society as much as society has a driving influence on science and what is being investigated.

Knowledge is also not just generated in an institution such as a

⁴⁶ Donald MacKenzie and Judy Wajcman, "Introductory Essay: the social shaping of technology", edited by MacKenzie Donald, and Judy Wajcman, *The Social Shaping of Technology* (Open university press, 1999), 3.

⁴⁷ Schaffer and Shapin, *Leviathan and the Air-Pump*, 3.

laboratory or university, but also from non-scientists working outside of such institutions such as on farms. Such knowledge is known as vernacular knowledge, a "non-elite"⁴⁸ kind of knowledge. As long as such knowledge is derived from experience and reproducible results from the implementation of such knowledge, vernacular knowledge can be considered a kind of science. Farmers and hobbyists can generate this kind of vernacular knowledge by their experience and expertise in cultivating koi. Japanese koi breeders are considered by Singapore hobbyists to be experts in koi cultivation, for example, and they produce vernacular knowledge of koi breeding and cultivation.

With the scientific knowledge production of koi, disease and the management thereof, the political ramifications affect how and what is studied about koi, depending on the historical context surrounding the researchers. Most importantly, historical and social context determines how scientific knowledge of koi is translated into aquaculture practices. Translation has much to do with the scientific knowledge involved with koi aquaculture in Singapore. Generation of scientific knowledge in Shapin and Schaffer's work on how the scientific theory and experimentation collided with politics shows a need to translate the scientific knowledge back into vernacular practice.⁴⁹ People need to translate the paradigm of scientific knowledge of disease and

⁴⁸ Helen Tilley, "Global Histories, Vernacular Science, and African Genealogies; Or, Is the History of Science Ready for the World?" *Isis* 101, no. 1 (2010): 112.

⁴⁹ Steven Shapin, Simon Schaffer, and Thomas Hobbes, *Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life: Including a Translation of Thomas Hobbes, Dialogus Physicus de Natura Aeris* by Simon Schaffer (Princeton, NJ: Princeton University Press, 1985).

aquaculture into their non-scientific practice, i.e. incorporating it into farming practice. Thomas Kuhn's important work *The Structure of Scientific Revolutions* defines paradigms as "universally recognized scientific achievements that for a time provide model problems and solutions to a community of practitioners."⁵⁰ In this definition, an agreed scientific atmosphere normalises what is or what isn't science. What should be considered when dealing with the politics and regulations of this scientific knowledge of koi aquaculture? In particular, who is generating the scientific knowledge of aquaculture and who is translating this knowledge farm practice and regulations? What are their motivations in choosing particular translations?

Within the koi aquaculture industry, there are several social groups of people who are involved in the generation of scientific knowledge, technological developments and farm practices, and in their different roles, affect how science is applied in regulations and vice versa. MacKenzie and Wajcman support a 'soft' determination of technology⁵¹ since they agree that the social, economic and political effects caused by technology is complex, but does not mean that technology does not have any effect whatsoever. Science and technology go hand-in-hand. While it is difficult to parse out exactly what is science and what is technology, it is clear that the development of science and

⁵⁰ Thomas S. Kuhn, 2nd ed., *International Encyclopedia of Unified Science. Foundations of the Unity of Science*, v. 2, No. 2 (Chicago: University of Chicago Press, 1970), viii.

⁵¹ Merritt Roe Smith and Leo Marx, eds., *Does Technology Drive History?: The Dilemma of Technological Determinism* (Cambridge, Mass: MIT Press, 1994)

technology is dependent on social pressures, and they in turn affect society. For example, Brian Arthur writes that economics has a strong prediction on the precedence of a particular technology, even if the other might be 'objectively' better or more efficient.⁵² The cyclical and influential nature society has on scientific knowledge generation and vice versa is important when considering translation of aquaculture science into actionable policy and regulation of the koi aquaculture industry.

Knowledge is not interpreted the same everywhere and therefore there is a need to integrate the localised histories of knowledge and science and yet managing to translate it into a global common conversation.⁵³ As koi in Singapore are largely bred and imported from Japan, the Singaporean farmers have to adjust their own farming practices to keep koi in the Singaporean farm. The scientific knowledge and farm practices of koi aquaculture in Japan has to be translated in a way to be meaningful in the Singaporean context. In order to make sense of local diversity in historiography and epistemology in global and general context, there has to be a way of translating local differences yet keeping the sense of diversity.⁵⁴ The systems of knowledge in different localities offer up various kinds of interactions between social

⁵² W. Brian Arthur, "Competing technologies with economic prediction", edited by Donald MacKenzie and Judy Wajcman, *The Social Shaping of Technology* (Open university press, 1999), 106-112.

⁵³ Carla Nappi, "The Global and Beyond: Adventures in the Local Historiographies of Science," *Isis* 104, no. 1 (2013): 108.

⁵⁴ Nappi, "The Global and Beyond," 103.

groups, such as local alternate forms of medicine and healing, and these "subaltern forms of knowledge"⁵⁵ are of increasing interest, particularly for what they might have to offer to science. The act of translating alternate systems of knowledge into the 'standard' form of science is a necessary task for analysis for the historian. This translation is necessary as historians have to translate information and knowledge across different systems of proof, evidence and value.⁵⁶ In this thesis, it is necessary to analyse the historical context of how the non-scientific practices in koi aquaculture is informed by scientific knowledge, which includes both vernacular science and 'normal' science, and how the same knowledge might be transferred and translated between Japan and Singapore, as well as between social groups.

1.5 Translation & Translocation: Constructing and maintaining koi in Singapore

Koi sits in a nexus of complicated multiplicity. It has been translocated from Japan to Singapore, bringing along a web of both the husbandry practices, the scientific knowledge, and its relationships with its biotic and abiotic environment, which in turn have to be translated and adapted into the Singapore environment. For example, koi occupied a duality in minds of the people who keep the fish in Singapore thanks to the fact that they believed that Japanese judges are better able to

⁵⁵ Helen Tilley, "Global Histories, Vernacular Science, and African Genealogies; Or, Is the History of Science Ready for the World?" *Isis* 101, no. 1 (2010): 119.

⁵⁶ Nappi, "The Global and Beyond," 108.

judge the koi. Singaporean hobbyists were unable to understand the mysterious workings of these criteria, which in turn is an issue of translation, for Japanese judges were unable to even express themselves fully to the audience. In this sense, it is very much like Stacey Langwick's idea of translation in that the approach to body and disease are different and results two different 'diseases',⁵⁷ which leads to different approaches. From the Japanese judges' point of view, they were viewing the fish as is, and the Singaporean hobbyists were viewing the fish and the judges' results and trying to puzzle out the criteria and ranking from there. Singapore koi hobbyists had to translate ideal koi traits from various judged koi, and construct what an ideal koi would look like. They were attempting to induce what the unspoken criteria of perfection was for koi based on their interpretation of the reasoning of Japanese judges. While Japanese judges have defined the standards of the ideal koi in terms of body shape, pattern, skin quality, and other factors, and therefore are able to judge an individual koi based on this criteria, Singaporean hobbyists were, due to the incompatibility of language, only able to look at winning koi and induce the kind of traits that a koi should have in order to win a competition.

Singaporean farmers and hobbyists had to translate winning koi into an actionable rubric that they can understand. In the case of a koi

⁵⁷ Langwick, Stacey A. "Devils, Parasites, and Fierce Needles: Healing and the Politics of Translation in Southern Tanzania". *Science, Technology & Human Values* 32, no. 1 (1 January 2007): 88-117.

that won a competition, Japanese judges determined the winning koi based on a rubric of pre-defined traits. Singaporean hobbyists, on the other hand, judged koi based on traits they assumed had graded highly and comparing the koi to previous winners. They were given the ideal koi, and then used inductive reasoning to determine the factors that make it ideal, before implementing the aquaculture practices of trying to attain this ideal with their own koi. Linguistic translation even concerns the fact that to most non-Japanese, the term 'koi' is used to refer to the colourful fish that are so familiar in Singapore's ponds; but the word koi in Japan, generally, actually represents the edible carp, officially called magoi. Even if two people were to converse, one Japanese, and one not, in the same Japanese language, using the word 'koi' in the conversation brings up two different images to the participants of this conversation – and a Japanese might surprise his conversation partner by saying that yes, he does eat koi sashimi!

Translation is again necessary in the context of koi disease, particularly with the advent of a koi-specific virus, the Koi Herpes Virus (KHV) named in 2000. Translation of scientific knowledge about this disease and how it related to koi was necessary for people to deal it. Where contemporary scientists deal with the disease in terms of the afflicting parasite or organism, hobbyists and farmers for the most part deal with the afflicted 'body', or the fish.⁵⁸ This manifested in the way

⁵⁸ Langwick, "Devils, Parasites, and Fierce Needles," 89.

hobbyists deal with disease for their fish by isolating the afflicted fish after observation of its behaviour and appearance, and treating it generally. Most treatments for ornamental fish are general actions. Usually the first line of defence is to attempt to remove all afflicting conditions from the fish by the changing of the water. Disease management and biosecurity, however, required testing for the organism. This was done either by testing a sample (which can be an animal or water) to determine the presence or absence of particular disease causing organisms, and the results were interpreted into a meaningful statement in order to determine future actions. The different set of dualities will be examined in more detail in subsequent Chapter 4, in the examination of disease and the role of biosecurity in the regulation of the ornamental trade industry.

Analysis of koi in Singapore also had to involve the concept of translocation, as koi is not a native species in Singapore. Translocation is when a non-native species is introduced into a new environment, usually bringing with it its own abiotic and biotic relationships.⁵⁹ Koi brought into Singapore from Japan not only interacted with the hobbyist and farmer, but also interacted with the water it is surrounded in, while also acting as a host of microscopic entities. Koi then becomes an item of analysis in biogeography and global economy. In other historiographical

⁵⁹ Donald Kennedy and Marjorie Lucks, "Rubber, Blight, and Mosquitoes: Biogeography Meets the Global Economy," *Environmental History* 4, no. 3 (1999): 370.

analyses, biological entities are usually translocated across different continents but within the same climate.⁶⁰ For example, the lateral movement of rubber across continents but within similar climates also resulted in the transportation and translocation of disease. The spread of disease is also important in this discussion but I would like to draw the attention to the unique status of koi. It was moved from a temperate climate, specifically Niigata, Japan, to tropical Singapore. Much of the differences in the koi kept in Japan versus that of in Singapore, such as intensity of colour, growth rate, have been attributed by hobbyists to the difference in climate and geography. The water conditions are different, and they don't experience winter in Singapore. Further reinforcement of these ideas are the fact that plenty of goldfish and koi manuals written in English, the main medium of communication in Singapore, and they all mention habits such as allowing koi to be left in deep ponds during winter. Someone living in the tropics would then assume from these manuals that koi require an exposure to heavy snow, especially since Niigata is well known for experiencing heavy and deep snowfall in the mountains. In Singapore, some koi hobbyists even use cooling units for their ponds or tanks, which, again are an attempt to imitate the climate that they believe koi had originated from. The translocation of koi to Singapore brought with it a network of assumptions and practices, and it needed to be translated into legibility. The koi might look the same

⁶⁰ Kennedy and Lucks, "Rubber, Blight, and Mosquitoes: Biogeography Meets the Global Economy," 369.

but it now exists in a different environment, and the practices surrounding it in Singapore are different from that of Japan. Successful translocation of this transnational fish required the translation of its relationship with its environment in Japan into quantities that humans could modify in order to recreate that environment in Singapore.

Koi acts as a medium through which microscopic entities travel as well, making the microbial also part of the global network through which koi connects Singapore, Japan and other nations. The movement of the non-native koi opened up the potential for biological risk. Physical symptoms exhibited by koi (such as swimming poorly, discolouration of the skin and death) are translated as indicators of these microscopic and invisible passengers, much like how red algal blooms became the manifestation of harm in the aquatic world.⁶¹ It is in the translation of these physical symptoms into a disease-causing pathogen that they became a signal for the enactment of biosecurity. That is, the appearance of disease resulted in the need to prevent or stop the disease from arriving in Singapore with imported koi. Why was this important? While koi was a translocated non-native animal, it was part of the ornamental fish industry, and the ornamental fish had become associated with Singapore's reputation for only exporting healthy fish. The history of this association is elaborated in Chapter 3. Microscopic pathogens threatened Singapore's reputation and the translation of

⁶¹ Kjell Ericson, "Making Space for Red Tide: Discolored Water and the Early Twentieth Century Bayscape of Japanese Pearl Cultivation," *Journal of the History of Biology*, 2016, 1-31.

scientific knowledge by scientists into official's regulatory protocols resulted in the enactment of biosecurity regulations.

1.5.1 Biosecurity: Origins from human health to animal

In Singapore, the enactment of biosecurity covers both human disease and animal disease. The term first came into being in 2000,⁶² but the concept itself was long in the making. Biosecurity has been defined by security scholars as a system of regulations and policies invoked to regulate the movement of biological entities across defined borders, in order to control those is considered to be biological threats to the functioning of both state and society.⁶³ Behaviours associated with enacting biosecurity can be traced back to the post-Cold War era as an off-shoot from the enactment of securitization around national boundaries. First of all, historians have written about how disease as a whole has been used as a reflection of politics⁶⁴, boundaries⁶⁵ and identities.⁶⁶ Historian Emily Martin had written about how disease had

⁶² Gregory D. Koblenz, "Biosecurity Reconsidered: Calibrating Biological Threats and Responses," *International Security* 34, no. 4 (2010): 96.

⁶³ Koblenz, "Biosecurity reconsidered: calibrating biological threats and responses." 96-132; Adam Kamradt-Scott, and Colin McInnes. "The securitisation of pandemic influenza: framing, security and public policy." *Global public health* 7, no. sup2 (2012): S95-S110.

⁶⁴ Cindy Patton, *Sex and Germs: The Politics of AIDS* (Black Rose Books Ltd., 1986).

⁶⁵ Niamh Stephenson, "Emerging Infectious Disease/Emerging Forms of Biological Sovereignty," *Science, Technology & Human Values* 36, no. 5 (1 September 2011): 616-37; Susan Craddock, "Tuberculosis and the Anxieties of Containment," in *Networked Disease*, ed. S. Harris Ali and Roger Keil (Wiley-Blackwell, 2008), 186-200; Matthew Gandy, "Deadly Alliances: Death, Disease, and the Global Politics of Public Health," in *Networked Disease*, ed. S. Harris Ali and Roger Keil (Wiley-Blackwell, 2008), 172-85; Paul Jackson, "Fleshy Traffic, Feverish Borders: Blood, Birds, and Civet Cats in Cities Brimming with Intimate Commodities," in *Networked Disease*, ed. S. Harris Ali and Roger Keil (Wiley-Blackwell, 2008), 281-96..

⁶⁶ Matthew K. Chew and Andrew L. Hamilton, "The Rise and Fall of Biotic Nativeness: A Historical Perspective," in *Fifty Years of Invasion Ecology: The Legacy of Charles Elton*, ed. David M. Richardson, 2011, 35-48; Howard Markel and Alexandra Minna Stern, "The Foreignness of Germs: The Persistent Association of Immigrants and Disease in American Society," *Milbank*

started to be envisioned as a foreign body invading the human body.⁶⁷ Similarly, Alfred Crosby's *Columbian Exchange*, states that disease could be conceptualized as not only an object of exchange, but also as a biological weapon, which Europeans employed kill the peoples already living in the South American continent.⁶⁸ Crosby's argument had been criticized as being limited, by neglecting the agency of the Amerindians in interacting with the animals and plants introduced⁶⁹ and thus the human-knowledge and awareness of the introduced biological entities.⁷⁰ However, the militarized, invasive conceptualisation of disease had been taken up by health regulating bodies. This particular translation of disease thus influenced the strategy taken by various international public health departments, and also influenced biosecurity issues. For example, biosecurity has sometimes been used together with bioterrorism. The fear that terrorist groups might use biological diseases or organisms as weapons. The militarized ideation that these scholarly works provide a framework for analysing how the perception of disease in Singapore as an enemy to security informed the actions of the regulating bodies in Singapore. In considering disease, the use of

Quarterly 80, no. 4 (2002): 757–88; John Morton and Nicholas Smith, "Planting Indigenous Species: A Subversion of Australian Eco-Nationalism," *Quicksands: Foundational Histories in Australia and Aotearoa New Zealand*, 1999, 153–75.

⁶⁷ Emily Martin, *Flexible Bodies: Tracking Immunity in American Culture from the Days of Polio to the Age of AIDS* (Beacon Press, 1994).

⁶⁸ Alfred W. Crosby, *The Columbian Exchange: Biological and Cultural Consequences of 1492*, vol. 2 (Greenwood Publishing Group, 2003).

⁶⁹ See for example, Elinor G. K. Melville, *A Plague of Sheep: Environmental Consequences of the Conquest of Mexico*, Studies in Environment and History (Cambridge [England] ; New York, NY, USA: Cambridge University Press, 1994).

⁷⁰ Marcy Norton, "The Chicken or the Iegue: Human-Animal Relationships and the Columbian Exchange," *The American Historical Review* 120, no. 1 (1 February 2015): 32.

militarized language to generally describe disease spread widely, and is fairly common in most public health materials but the agency of the invaded population is usually under articulated. For example, koi (*Cyprinus carpio*) is not passive population under attack by external disease, but instead should be considered to be part of a koi-disease relationship. Human attempts to translate knowledge about koi disease into biosecurity regulation is an act of human control and intervention.

The act of human intervention in the koi and disease relationship comes under the umbrella of biosecurity, and has to be analysed as such. Biosecurity is invoked when national sovereignty and safety are threatened by biological entities. The U.S. National Security Council designated HIV/AIDS a national security threat in February 2000, a historical first in the perception of diseases.⁷¹ The umbrella term of biosecurity was quickly expanded to include not just diseases that affected human populations, but diseases and other biological organisms that could adversely impact a nation's various industries such as agriculture and ecological purity. This positioning of biological entities as potential threats not only externalized certain kinds of biological organisms, but also defined others as endemic or native populations that required protection. While disease has always influenced international security, disease itself has not been seen as an international security threat until the beginning of the twenty-first

⁷¹ Koblentz, "Biosecurity reconsidered," 96.

century.⁷² Acceptance of redefined international security issues meant that biological threats could be cast as security issues themselves. This was done not just with a change of definition in security issues, but also by casting biological threats such as disease in militarized terms that could be easily incorporated into the accepted security rubric of the post-Cold War landscape. In contemporary terms, it has been suggested by scholars that biosecurity can be reconceptualised as a boundary object that takes different forms in order to mediate between competing domains and keep biological lives secure.⁷³

Other historians and scholars have attempted to recast disease causing microbes in a different light. For example, in analysing herpes viruses in elephants, Celia Lowe and Ursula Munster wrote that "herpes has turned on elephants in a way that may soon prove to be suicidal, since the virus cannot live without its host,"⁷⁴ giving the virus more agency, if a mindless one. While giving a virus agency seems to on the surface fall into a similar category of casting disease into invading armies, giving the virus a more regulatory function, in that the virus works in tandem with the immune system, implied a give-and-take, a balance. It is when the balance is upset that things go wrong and "the virus has become a killer."⁷⁵ Donna Haraway's concept of

⁷² Ibid., 99.

⁷³ Limor Samimian-Darash, Hadas Henner-Shapira, and Tal Daviko, "Biosecurity as a Boundary Object: Science, Society, and the State," *Security Dialogue*, 17 May 2016.

⁷⁴ Celia Lowe and Ursula Münster, "The Viral Creep: Elephants and Herpes in Times of Extinction," *Environmental Humanities* 8, no. 1 (May 2016): 142.

⁷⁵ Lowe and Münster, "The Viral Creep," 139.

methodological individualism cannot be used to comprehend this sort of imaginings, but instead Lowe and Münster suggest that "speculative imagination — modes of imaging what cannot be known but is nonetheless very real and consequential" is used to make sense of the world as disease has to be represented in various forms for humans to understand them.⁷⁶ The limits of such speculative imagination is unfortunately not acknowledged⁷⁷ and the scientific representation of disease invaders are taken as fact. In the effort to keep disease away from us, or protect the biological lives we in particular value, we cast disease as outsiders. Yet in fact, "no wild that exists outside the Anthropocene, Capitalocene, Plantationocene, or Chthulucene"⁷⁸ where these viruses and disease microbes could have come from to harm us. The envisioning of humans and the animals and spaces we want to protect as pristine, isolated untouched spaces does not take into account the interconnectedness of all these biological creatures, and removes the agency of humans within the biological systems, such as their influence on the koi-disease system existing on farms.

To sustain animals and humans despite diseases and invisible pathogens, the work of making these tiny pathogens visible became important. In order to make these pathogens such as viruses visible, the

⁷⁶ Ibid.

⁷⁷ Ibid.

⁷⁸ Donna Haraway, "Anthropocene, Capitalocene, Plantationocene, Chthulucene: Making Kin," *Environmental Humanities* 6, no. 1 (2015): 159-165.

methods developed to study viruses became useful in understanding other biological entities, and became relevant in general biology.⁷⁹ Virus and disease research proved to become fruitful areas of knowledge generation, disease research overlapping from medicine and agriculture into other aspects of biology and society.⁸⁰ The effort scientists put into researching the limits of disease provided answers to policy makers who are concerned with dealing with limiting or protecting particular biological populations of animals. This could change the way an industry's actors dealt with the biological entities that they are attempting to rear and culture.

KHV was a particularly lethal disease to koi and stood to have a large impact on the koi aquaculture industry. This provided the social and political impetus for scientists to generate more knowledge about KHV. Such social impetus can be driven by the lethality of a disease. For example, when historian Lisa Onaga examined the scientific knowledge that emerged from the study of pébrine, a disease that affected silkworm larvae, she noted that the disease "was dreaded because it efficiently decimated complete cohorts of silkworm larvae, was highly infectious, and ensured great economic loss."⁸¹ KHV was so-named because of its specificity in only affecting koi and its non-ornamental morph, common

⁷⁹ Angela NH Creager, "Where Tobacco Mosaic has led us", in *The Life of a Virus: Tobacco Mosaic Virus as an Experimental Model, 1930-1965* (University of Chicago Press, 2002), p 2.

⁸⁰ Ibid.

⁸¹ Lisa A. Onaga, "Bombyx and Bugs in Meiji Japan: Toward a Multispecies History?" *Scholar & Feminist Online* 11, no. 3 (2013), <http://sfoonline.barnard.edu/life-un-ltd-feminism-biosciencerace/bombyx-and-bugs-in-meiji-japan-toward-a-multispecieshistory/0/#sthash.QwEEklam.dpuf>.

carp. The decimation of large populations of koi-made KHV a lethal disease that was of great economic concern to countries that relied on koi and common carp. One of the first concerns that scientists and industry interest groups were interested in was whether KHV was a lethal variant of other viral diseases that already existed, and could be guarded against, or whether it was a new disease. Part of the frantic investigation by scientists at its first appearance in America and Israel was to determine whether KHV was significantly different from other carp viruses. Its vague outward symptoms led to the need for a new paradigm in disease identification as the method at the time was too vague and uncertain. The new disease resulted in a development of a relatively new diagnostic tool to distinguish KHV from other diseases. My research showed that the human attempt to intervene in the relationship between koi and KVH as discussed in Chapters 4 and 5 resulted in the 2004 and 2006 enactment of biosecurity on the respective aquaculture industries in Japan and Singapore, with their various consequences. But due to the limitations of our only being able to scientifically represent the viruses and animals in isolation, the human ability to deal with these sort of diseases are also limited. Policy makers and health officials used "speculative imagination" to make sense of disease,⁸² which is discussed in Chapter 3, and it resulted in the predominant conceptualisation of the disease-host dynamic where the

⁸² Ibid.

host is attacked by the external disease. The imagined concept resulted in the translation of knowledge of KHV into specific kind of biosecurity that is enacted by various human entities in an attempt of intervention. Part of the investigation into disease by scientists was to try to translate the disease entity into usable imaginings.

The first step in attempting to imagine KHV was the attempt to make visible the virus in an intelligible fashion. Angela Creager argued that in disease studies, model viruses "showed how to make the enemy visible."⁸³ The act of making disease visible was in order to give form to the at-first unknown entity. This unknown entity in facts provokes scientists into initiating studies to redefine the entity, and changes the understanding of the entity, giving it new properties and developing new protocols around it.⁸⁴ That is, the when an entity becomes relevant to scientists and there is a drive to investigate it, the entity catalyses the start of a generation of an entire body of new scientific knowledge for various reasons. The appearance of a new mysterious disease in an economically valuable fish population thus catalysed the study of this disease to first identify it, understand it, and then to control it.

Regulating bodies like the Ministry of Health in Singapore translated this knowledge into the old familiar military metaphor, and

⁸³ Angela NH Creager, "The War against Polio", in *The Life of a Virus: Tobacco Mosaic Virus as an Experimental Model, 1930-1965* (University of Chicago Press, 2002), 184.

⁸⁴ Laura Stark and Nancy D. Campbell, "Stowaways in the History of Science: The Case of Simian Virus 40 and Clinical Research on Federal Prisoners at the US National Institutes of Health, 1960," *Studies in History and Philosophy of Science Part C: Studies in History and Philosophy of Biological and Biomedical Sciences* 48 (December 2014): 228.

this allowed a militarized strategy for the dealing with identified biological security threats such as KHV. Singapore's Ministry of Health utilized these militarized terms in talking about human diseases, particularly those that have been cast as having non-local origins, such as the Avian Flu of 2009. Strategies such as monitoring of individuals, quarantine and isolation in order to remove the foreign disease echoed strategies in dealing with military threats. Treating disease as a military threat included the Singapore Ministry of Health broadcasting bulletins that called for heightened awareness, as well as increased monitoring of individuals who enter Singapore. First, however, disease had to be made legible and understandable to be translated into practices that could control it.

Part of Singapore's reaction to disease in both human and fish was in due to the colonial perception of disease in the late nineteenth century. The colonial narrative of differences between the tropical residents and the colonial became embedded into disease and health, where the diseases are considered to be exacerbated and turned more lethal in the tropics, while colonial subject was considered the carrier of disease.⁸⁵ The sanitation levels of those who were considered 'natives' in colonial Singapore was often compared unfavourably to that of the colonizers',⁸⁶ and thus in Singapore's entering independence,

⁸⁵ Lenore Manderson, *Sickness and the State: Health and Illness in Colonial Malaya, 1870-1940* (Cambridge University Press, 2002), 76-77.

⁸⁶ Manderson, *Sickness and State*, 83.

necessitated a shedding of the status of being a hotbed of disease. The movement of exotic, introduced ornamental animals into Singapore's newly sanitized environment therefore opened the doors to foreign disease.

With the concept of disease firmly established as an external militarized threat, militarized defence against disease has also been established in Singapore, especially since 2003's SARS pandemic. This meant that all diseases, even if they did not directly impact a human population, were also conceived as requiring militarized action. New diseases that entered Singapore, by translocation or otherwise, were translated to fit this paradigm. In consequence, the actions that were taken against the KHV epidemic in Singapore was very similar to that taken against human diseases.

Various factors resulted in Singapore's need for security in the late 20th century which coalesced into the urge to control the movement of micro-biological entities, and the concept of biosecurity became the framework through which Singapore's government officials enforced control over Singapore's borders. The fact that this was applied to the ornamental fish industry could be traced back through all the other animal-based industries that were identified to be the source of zoonotic or animal-sourced diseases. The translation of the scientific imaginings of KHV into militarized concepts that humans could understand resulted in actions taken to control these imagined entities, specifically

in the form of biosecurity enactment in Singapore's koi aquaculture industry. The translocation of koi from Japan to Singapore necessitated human effort in generating knowledge about koi's relationship to its environment that could be translated into terms that people could understand in order to recreate the Japanese environment in Singapore. I therefore investigated how koi from Japan was used to produce scientific knowledge in the act of cultivating and sustaining them in Singapore, and how this scientific knowledge was converted into aquaculture practice in Singapore from 1965 to the present.

1.6 Research Questions

Translocation of koi in Singapore resulted in a necessary translation of koi aquaculture practices between countries. In order to examine this broad idea, I looked at three main questions. First, how and why did ornamental aquaculture practices in Singapore change over time? The history of ornamental aquaculture in Singapore would chronicle the kinds of practices that farmers in Singapore developed, as well as the historical context that will allow the successful transplantation of koi into Singapore's landscape. I will be focusing my research on Singapore in the 1950s till the present day, and investigating how aquaculture practices in koi farming changed during that period, as a survey of local newspapers in Singapore showed that aquaculture increased in article number over time since Singapore's Independence in 1965, and koi culture in specific showed a definite trend from double

digit articles in the decade following Independence to more than two hundred articles by the 1990s.

Second, what did Singapore take from Japan's koi cultivation practices, and how did they change them? Koi is a large ornamental fish, and is usually displayed and bred in ponds. There is a strong indication that Japan is considered by Singaporean hobbyists to be the repository of koi breeding and rearing techniques, since dealers such as Singaporean Max Koi Farm takes care to point out that their founder "spends over four months in Japan and makes at least ten trips. A commitment that has allowed him special access to top koi breeders, testing growing techniques, experimenting with nutrition in koi feed, developing indepth [sic] knowledge of various bloodlines,"⁸⁷ a sentiment echoed by most koi dealers in Singapore. As I had mentioned earlier in this chapter, the successful translocation of koi to Singapore is a result of different farm and husbandry practices, which the various people involved in the industry are constantly translating and reinterpreting from their understanding of Japanese husbandry practices. Koi culture places a definite emphasis on the origin and stock breed of the fish. Koi hobbyists and farmers in Singapore, for example, tend to look towards Japan as models and experts in both breeding and rearing techniques, and therefore even hobbyists prefer to try and emulate koi rearing in Japan. Certain practices might have been

⁸⁷ "About Us," Max Koi Farm, accessed Dec 28, 2017, <http://maxkoifarm.com/aboutus.php>.

imported from Japan, but modified to work in the Singapore context.

How have these practices been modified, and what are the results?

The final question I am trying to answer concerns the kind of knowledge that is derived from aquaculture, using the koi carp as the embodiment of said knowledge. At present, aquaculture produces large amounts of scientific knowledge which people who practice aquaculture utilize within establishments and institutions. There is also tacit knowledge and technique that is generated by farmers and hobbyists. Such knowledge can be about the species being cultured, or as far ranging as the environmental and global impact. It not only includes the scientific knowledge scientists and researchers would gain from aquaculture practices, but also changing perception of the environment, sociological dynamics and networks and the impact on different cultures. Hence the question is what is the context in which scientific and non-scientific knowledge is derived and used in aquaculture? What is the kind of knowledge produced? How are these kinds of knowledge translated and utilized by each group and institution? This question can only be answered after the previous two questions have been explored.

Aquaculture is not merely about the end products of fish for display or consumption. The practice of aquaculture involves increasing control of the life-cycle of the target fish and its environment. When discussing aquaculture practises, I first have to define the practice of aquaculture and which aspect of aquaculture I wish to investigate.

Latour and Woolgar mention that while the study of sociological phenomena of the practice of science can be due to the fact that scientists are social beings, "but they are essentially peripheral to the practice itself,"⁸⁸ wherein practitioners of science view scientific knowledge and practice as separate to the scientists themselves. This applies to the practice of aquaculture as well. Scientists and practitioners of aquaculture generate scientific knowledge but communicate such knowledge to each other at a removed sense of self, and while sociological factors such as politics can and will impinge on the practice of aquaculture, the practices itself seem to be existing in isolation of practicing peoples. Aquaculture generally encompasses both freshwater and marine organisms, but in many marine species, not all stages of the life-cycle of the organism are controlled by humans. Some freshwater species such as goldfish and koi, on the other hand, can be managed entirely by humans, much like terrestrial farm animals like cows and sheep. In fact, scientific breakthroughs were considered great and laudable when an individual or several individuals were able to accomplish a new step in closing the life cycle of aquatic animals by being able to hatch fish eggs or oyster spat. In Singapore, the cultivation of koi is not complete in that most of the koi are imported as adults from Japan rather than bred. However, as translocating koi is not just a physical process but also involves translocating it and its relationship

⁸⁸ Bruno Latour and Steve Woolgar, *Laboratory Life: The Construction of Scientific Facts*, 2nd ed. (Princeton University Press, 1989), 20-21.

with disease to Singapore, much of the knowledge surrounding this system had been translated into regulation and changing practices in order to control the KHV aspect.

In the attempt to control KHV, first KHV has to be understood and made legible. It has to be translated from symptoms of fish into an entity that can be interacted with and deal with. Hannah Landecker wanted to examine how humans consider and interact with living organisms, and even the redefinition of living material⁸⁹ by trying to reposition cells as biotechnology. I too believe that the reason why certain aquaculture practices that include inducing of spawning and eggs hatching are lauded is because of the need and desire by people who practice aquaculture to gain more control over the species they are concerned with, and ultimately trying to reposition aquaculture as a technology. As in many of the life-sciences, the engineering ideal of biotechnology had been on the rise since the early 1890s and scientists have been trying to increase control over many aspects of life in biology. Hence the important announcement by the PDD on the success on being able to induce spawning in koi. In trying to understand more about KHV and its relationship to koi, Singaporean regulators were attempting to gain more control over koi and its relationships with disease pathogens. In order to simplify terminology, when a particular practice of aquaculture only controls one part of an organism's life cycle,

⁸⁹ Hannah Landecker, *Culturing Life: How Cells Became Technologies* (Cambridge, Mass: Harvard University Press, 2007), 2.

I shall refer to it as 'incomplete aquaculture', so that I can differentiate between practices that encompass the entire organism's life cycle, which will be referred to as 'complete aquaculture' or 'closed aquaculture'. Aquaculture is an umbrella term that includes both incomplete and complete aquaculture practices. One of the most obvious differences between koi cultivation in Singapore and Japan is that Japan has complete aquaculture of koi, while not in Singapore.

In the time period from 1965 to the present day, the global practice of industrial aquaculture had gone from being the answer to eradicating poverty with cheap mono-cultured protein to becoming a strongly debated topic with regards to sustainable practice and environmental impact. There is an obvious effect on the kind of research and information that comes out of industrial aquaculture. However, there are few historical studies of koi and other ornamental fish. The development of ornamental aquaculture species into commodities is strongly affected by economic and social factors not immediately obvious the way industrial food aquaculture is. Singapore is currently the leading producer and exporter of ornamental fish yet the farmers and breeders of koi highly value Japanese breeds direct from Japan, as evidenced by the various koi dealers in Singapore claiming to only provide fish from the best Japanese parent-stock of koi.

In this thesis, I identified distinct groups of people involved in aquaculture: statutory board officials who regulate the industry in

Singapore, scientists, farmers and workers of both food and ornamental fish farms, and hobbyists. There were many individuals who overlap within these groups – scientists who work in the statutory board, hobbyists who turned their hobby into a career by becoming a fish farmer and so on. How these many groups generate knowledge and how this is translated between these groups and at what interfaces, using the koi carp as an embodiment of this knowledge is currently uncharted, and should be clearly outlined. To what extent do each group wish to exert control over the koi fish in the pursuit of their goals? I wish to understand the historical context that koi is embedded in in Singapore, and the study of the social networks would elucidate how knowledge is translated and transmitted through these social networks via the medium of the koi. As a multidisciplinary project, this thesis has to merge various disciplines within a historical context.

1.7 Methods: Data collection

Koi aquaculture in Singapore had its roots in the ornamental fish hobby, with many hobbyists being exposed to other ornamental fish before deciding on keeping koi. While general ornamental fish farms in Singapore started from farming families that had branched into the more profitable ornamental fish such as breeding guppies and discus and eventually dealing in larger diversity of ornamental fish species, some of whom like Nippon Koi Farm's Pay Bok Seng eventually started investing in entirely koi. Other mono-culture koi farms like Max Koi

Farm, Zion Koi Farm and Diamond Koi Farm were started from koi hobbyists who were able to turn their hobby into a career, and these owners maintained, and continue to maintain strong emotional and social links to the local hobbyists as well as connections to international dealers and Japanese breeders and farmers. For example, Max from Max Koi Farm is well-known in the dealer community internationally; several Japanese personnel involved with the industry had mentioned him by name.

Most koi farms in Singapore are essentially dealers of koi. The Singapore farm imported koi from Japan and kept them till they are of marketable size before selling or exporting them, and therefore do not practice complete aquaculture. Part of the reason is due to the types of farm licenses they can have. Breeding and dealer licenses are separate and for several of the farmers, obtaining a breeding license on top of the dealer's license is too much effort. In addition, several of the farmers have mentioned to me that the declining hobbyists in the local scene makes having a breeder's license impractical and also more prone to loss of revenue in the event a disease is detected. The location of most of the koi farms are in the Lim Chu Kang area; the area had been earmarked for agricultural use by the AVA. I had visited these farms to observe operations, conducting informal conversations with workers and farmer operators, as well as scientists, and obtained the 'lay of the land', and making recordings of activities on the farms to establish an

ethnographic landscape of both food aquaculture and ornamental aquaculture. Several of these activities include the importing of koi from Japan and koi competitions held on Max Koi Farm premises, as well as koi sorting where young unsuitable koi are culled. Many contemporary fish farms in Singapore farm freshwater fish, for ornamental or food purposes. On interviewing farm owners and workers I discovered the kinds of practices used in the farms and how it relates specifically to Singapore's regulatory arm, the AVA, and how intertwined the AVA and farmers and hobbyists are. Most of Singapore's koi farms had not had their roots in food fish farming, so the majority of the koi farmers had instead branched out to other aspects of the koi hobby in an effort to stay afloat. Only Nippon Koi Farm had turned to food farming in an attempt to obtain governmental funding and sponsorship. An ethnographic survey in the terms of informal interviews and conversations with members of each group highlighted the sort of information is used by the people within the different social groups.

In comparison, many Japanese koi farmers in Niigata had been breeding koi for at least two generations, several of whom had also been farming rice concurrently. Interviews with Japanese government officials and koi farmers seemed to show that most of koi farmers export the majority of their koi overseas, as much as eighty percent. In terms of aquaculture practice, farmers seem to readily seek advice from officials and the officials involve farmers with their own scientific experiments in

breeding of koi.

Most of my field work was accomplished between June 2015 to the end of 2016 in both Singapore and Niigata Prefecture, Japan. The main bulk of these document sources resulted from when I conducted semi-structured qualitative interviews. Several of my interviewees pointed me to documents like *The Singapore Journal of Primary Industries* and granted me access to the bulk of the *Aquarama Conference Proceedings*. I was also able to attend several events such as koi competitions and auctions from 2015 to 2016, with the Agri-food and Veterinary Authority officers kindly granting me access to the last Aquarama held in 2015. This and other events allowed me to carry out active participant observations, which formed a large part of my data and analysis. Reliability and validity of my data was confirmed by checking information against different sources of data collection. Using conventionally historical methods of text-based analysis with socio-scientific qualitative methods of oral interviews and participant observations as they are useful to get at knowledge generation in biology, especially in applied settings that intersect with commerce, governance and the international. I combined a thematic analytical method of analysing document texts⁹⁰ with the embedded participant-

⁹⁰ Hannah Landecker, *Culturing Life: How Cells Became Technologies* (Cambridge, Mass: Harvard University Press, 2007).

observation techniques that Shamus Khan⁹¹ and William Foote⁹²

1.7.1 Analysis of data

In this project, the data collected were primarily qualitative. My interviews were semi-structured, and observations were recorded in video and with thick descriptions. According to Clifford Geertz, thick description is necessary in order to understand science by observing what its practitioners do. The descriptive renderings of actors within the aquaculture industry allows for an interpretation of why they do what they do, while placing their actions into social context.⁹³ Published primary sources were coded and analysed using thematic analysis as defined by Virginia Braun and Victoria Clark⁹⁴ and placed in context with the thick descriptions. These published primary sources were also used and produced by the people within the field, and thus provided rich details that oral interviews or conversations might miss out.

Primary sources comprised of published papers, some journal articles from the now defunct *Singapore Journal of Primary Industries*, Aquarama Conference proceedings, newsletters produced by the AVA and manuals used by the various people in the ornamental fish industry. I used these primary sources as ways to parse out the attitudes

⁹¹ Shamus Rahman Khan, *Privilege: The Making of an Adolescent Elite at St. Paul's School* (Princeton University Press, 2010).

⁹² William Foote White, *Street Corner Society: The Social Structure of an Italian Slum* (University of Chicago Press, 1955).

⁹³ Clifford Geertz, "Thick Description: Toward an Interpretive Theory of Culture," *Readings in the Philosophy of Social Science*, 1994, 213-231.

⁹⁴ Virginia Braun and Victoria Clarke, "Using Thematic Analysis in Psychology," *Qualitative Research in Psychology* 3, no. 2 (2006): 77-101. Braun and Clarke defined thematic analysis as "a method for identifying, analysing and reporting patterns (themes) within data."

of the groups of people involved in the industry, using a qualitative method of analysis by coding and analysing the emerging themes. While these published materials might depict a chronicle narrative in scientific research and understanding of fish aquaculture, the actors within the industry use these sources nonlinearly, and thus a meta-analysis requires nonlinear thought. The different themes that arise from the data also produce different histories that occur concurrently, such as the history of water management versus the history of ornamental aquaculture. Tracing a historiography of the ornamental fish industry cannot easily be done in a linear or chronological fashion. Such a chronological depiction of history would not only be too simplistic and lends itself to the fallacy of determinism⁹⁵ but also misrepresent the thematic issues that arise from the study of this subject. Contemporary historiography is now mainly thematic, as such my chapters represent. A non-linear historical study of the industry also allows various sites and people within the industry to be brought forth in clear importance, and relating these sites to the thematic discussion I will follow through with.

This thesis also investigates the emergent theme of biosecurity from the lenses of translation and translocation which link the various aspects of the industry, drawing them together in as subtle a way as fish might swim through one spot to the next. The stories are all centred on

⁹⁵ James Clifford, *The Predicament of Culture* (Harvard University Press, 1988), 329; Kerwin Lee Klein, *From History to Theory* (Berkeley: University of California Press, 2011), 103

the koi, but the actions performed and the thoughts and attitudes of the people involved in the fish are in the real interest. Various actors involved in koi aquaculture have different view-points, different goals and different perceptions of the fish and each other; and in some cases, several of them perform different roles at different times, thus making it difficult to lay them out in a simple sociological fashion. The complexity of this data and the people involved is what makes this topic rich and interesting, and even the fish itself lies in a hybrid role. Koi is both a product of human driven aquaculture and an aquatic pet. In a very special way, koi represents the ornamental fish industry in Singapore but does not represent Singapore, while koi itself invokes images of Japan and Japanese-ness to the koi hobbyists.

With so few people currently involved and alive in the industry, quantitative data would be insignificant and instead deprives this project of the richness that comes from personal experiences in the various aspects of the industry. Furthermore, the key persons within the industry also play multiple roles. Officials in the AVA (Formerly PPD) both play regulatory and scientist roles, farmers could be both farmers and hobbyists, hobbyists could be also be regulatory officers. While these boundaries between these roles can be murky and ill-defined, several individuals made distinctions between their multiple roles. The industry being so small even in its beginning makes it difficult to gather statistically significant numbers to make quantitative analytical methods

relevant.

All my data was compiled in electronic form where possible, to allow easy referencing and archiving. Interviews were recorded with a digital voice recorder, and transcribed manually. Published materials, such as conference proceedings, were scanned or photographed. These were then categorised by source. Transcripts of interviews and published papers were reviewed and coded manually, following Saldana's *The Coding Manual For Qualitative Researchers*.⁹⁶ The First Cycle of coding of my initial collected data was done by reading through the transcripts and published material using koi or ornamental fish as descriptive codes, and then to various scientific themes related to them, such as disease, water management, genetics or breeding, and the history of ornamental fish in Singapore. During the coding of the data, major themes such as water management and disease, particularly pertaining to Koi Herpes virus (KHV), emerged from both interviews and published works. The data was reviewed again looking specifically for mentions of KHV and disease management. The coding process was repeated cyclically, and refined to develop into two major themes 'water quality management' and 'biosecurity'.

As a qualitative study, the themes that emerged from the first review of initial data were refined and I returned to my data, looking

⁹⁶ Johnny Saldana, *The Coding Manual for Qualitative Researchers* (SAGE, 2009). Of particular help was the first chapter, "An Introduction to Codes and Coding." As my data set was small and relatively manageable, I decided against using a coding program like NVivo, and coded my data by hand.

specifically for more details on KHV. During subsequent interviews, I made special note when interviewees mentioned disease or disease-management and enquired further about them, relating the disease in Singapore to other themes such as how the management might be different in Japan, for example. I also attempted to record the way my interviewees interpreted scientific knowledge in the process of their aquaculture work. The constant return to the data and back to collection and moving between the scientific and non-scientific was similar to Helmreich's attempt to work *athwart theory*, where "one that does not take for granted the difference between things and forms of explanation or abstraction, tracing instead how these items exist in alignment and tension."⁹⁷ Once I found that no new themes emerged from the review of my data, I considered the data collection to be saturated, and analysis mostly complete.

1.7.2 Semi-structured interviews and Participant observation of Aquaculture in Singapore

Latour and Woolgar had spelled out the difficulty of trying to conduct meta-research on the practice of science itself, because Latour and Woolgar were trying to analyse how scientists practiced science without having to understand the actual scientific research being

⁹⁷ Helmreich, *Alien Ocean*, 23.

produced.⁹⁸ In this way, I also attempted to perform a meta-research on the practice of the farming practices of koi aquaculture in Singapore and Japan. Jonas Salk summarized Latour's methodology as embedding himself into the work of a laboratory, observing and recording the processes of scientific research.⁹⁹ Helmreich also wrote of the difficulty of "writing up an account of a people's practices" in order to "speak beyond an instance of fieldwork."¹⁰⁰ In participant observation, it is a conscious choice as to the level of embedding necessary to obtain just enough information yet retain the distance necessary for analysis. I did not embed myself as deeply as presented in Latour and Woolgar's work, as the koi aquaculture industry turned out to have several organisations and affiliated groups. Embedding myself in one farm would mean losing the opportunity to observe the rest of the industry from an outsider perspective. Instead, I chose to overtly identify as a researcher with an interest in the koi hobby and aquaculture, and became involved with the Singapore koi club in a volunteer position. This was somewhat like Shamus Khan's work in embedding himself in a school as a teacher,¹⁰¹ but allowed me the flexibility to engage with government officials and scientists. Various kinds of people were involved with the

⁹⁸ Bruno Latour and Steve Woolgar, "Preface to Second Edition (1989)," *Laboratory Life: The Construction of Scientific Facts*, 2nd ed. (Princeton University Press, 1989), 273-275.

⁹⁹ Jonas Salk, "Introduction," in *Laboratory Life: The Construction of Scientific Facts*, 2nd ed. (Princeton University Press, 1989), 11-14.

¹⁰⁰ Stefan Helmreich, *Alien Ocean: Anthropological Voyages in Microbial Seas* (University of California Press, 2009), 21.

¹⁰¹ Shamus Rahman Khan, *Privilege: The Making of an Adolescent Elite at St. Paul's School* (Princeton University Press, 2010).

practices and regulation of aquaculture, and the different groups had different practices associated with koi, which necessitated my flexibility in observing as much of their practices as possible.

Ethnographic information and formal semi-structured interviews with specific persons from each group were used to highlight the travel of knowledge between groups and how the practices changed over time, and between the kinds of aquaculture practices. I named informants who were willing to be named, and anonymized those who did not wish to be named. My field studies in Japan were mainly participant observation of farming practices by Japanese farmers, research and regulatory practices by Japanese officials. I also conducted semi-structured interviews with farmers, researchers and officials in Japan with the help of a translator. I unfortunately was not able to talk to Japanese hobbyists and therefore cannot compare practices of Japanese hobbyists to that of Singaporean hobbyists.

1.7.3 Oral Histories: Personal Interviews

I conducted semi-structured interviews with sixteen people who were informed on koi aquaculture. These included people from the Agri-food and Veterinary Agency (AVA) of Singapore, Niigata Prefecture Inland Freshwater Fisheries Experiment Station, Singaporean and Japanese farm owners and workers, hobbyists, and scientists. My interviewees comprised of two academic scientists, five farmers and

workers, eight hobbyists, four government officials (including Japanese officials). However, many of these interviewees fell into more than one category. They could be both scientist and government official, for example, or hobbyist and farmer, and therefore it was not possible to perform a quantitative survey of set number of individuals wholly from each social category. Furthermore, the number of people who were involved were so intricately linked to each other that the absolute numbers of individuals were less important than attempting to map the interpersonal relationships they had with each other. When I first started interviews, I realised that the number of koi farms was very small, and the community of koi hobbyists was fairly insular. In order to get into contact with each of my interview subjects, I used snowball sampling,¹⁰² which had the advantage of utilizing the strong interpersonal relationships that the individuals within the koi hobby and aquaculture industry had with each other. Such contact also increased the trust I had from each new informant since I was a friend of a friend. It meant that I was rapidly contacting key figures of the industry and hobby. However non-random sampling is introduced and may have some drawbacks, such as sampling biasness.¹⁰³ As a social research project, however, non-randomness is inherent in social situations such as this project and therefore the non-random sampling

¹⁰² Leo A. Goodman, "Snowball Sampling," *The Annals of Mathematical Statistics* 32, no. 1 (1961): 148-70.

¹⁰³ For example, A. C. Ghani, C. A. Donnelly, and G. P. Garnett, "Sampling Biases and Missing Data in Explorations of Sexual Partner Networks for the Spread of Sexually Transmitted Diseases," *Statistics in Medicine* 17, no. 18 (n.d.): 2079-97.

was inevitable, particularly when the number of people involved were so few.

One particularly important limitation in non-random sampling was the lack of viewpoints. While other informants had mentioned names of certain characters, these people turned out to be prominent political figures and none of my informants were forthcoming with their contact information. It was difficult to get these people's time for interviews on what they might now deem a somewhat frivolous hobby and thus their viewpoints were regretfully not included in this project. With a longer fieldwork period, it would be possible for an investigator to integrate themselves into these people's circles to obtain these interviews, but that is not possible at this point of time.

During my interviews, I had noticed that many of my informants were men, something that even my interviewees had mentioned. As many other academics have noted, histories written that privilege the male view-point can be lopsided and thus problematic. In my research, I have tried to analyse my data with an awareness of the gendered-ness of the industry. Many studies on pets and leisure activities involving animals involved gendered-ness of the people involved,¹⁰⁴ which is related to how these activities were important to expressions of masculinity and their impact on the economy. There were few female

¹⁰⁴ For example, the studies by Leeworthy on greyhound racing and working class culture (2012) and Johnes' study on pigeon racing and working-class culture in Britain (2007) were examples of male-dominated activities.

koi hobbyists. The women whom I did see and talk to in the course of my fieldwork were wives of hobbyists or farmers. They are definitely integral to the industry in that farmers' wives are also involved in the running of the farm, communication with buyers and suppliers, such as Mr Pay's wife Stella. These hidden figures probably play a large role in the decision making of the running of a farm, or in the hobbyist's decision to set up a pond or purchase a fish because of shared finances and space. However they do not identify as hobbyists or being interested in koi beyond the business. Their role tended to be marginalised, much like women's role in silk manufacture in the late Imperial China was minimised.¹⁰⁵ Male hobbyists on the other hand made hobbyist groups to legitimize their hobby and presence, and expected to be taken seriously by government officials and farmers. Like how pigeon racing was an expression of masculinity in working-class Britain before the 1950s, the keeping of koi could also be an expression of masculinity, a refuge from domesticity.¹⁰⁶ While gender is very much integral in scientific knowledge production,¹⁰⁷ gender would shift the focus of my analysis from translation and translocation of knowledge generation.

1.7.4 Document Sources and Knowledge Generation in Aquaculture

This study had been conducted mainly in Singapore. Sources for oral history were limited, as most farmers were not able to speak

¹⁰⁵ Francesca Bray, *Technology and Gender: Fabrics of Power in Late Imperial China* (Univ of California Press, 1997).

¹⁰⁶ Johnes, "Pigeon Racing and Working-Class Culture in Britain, C. 1870-1950," 372.

¹⁰⁷ I. Donna Jeanne Haraway, *Simians, Cyborgs, and Women: The Reinvention of Nature* (New York: Routledge, 1991), 109.

English and I had only limited time to gain access to them via contacts. Hence, my oral histories were comprised mainly of interviews with Japanese regulatory officers who were able to speak English and their contacts via a translator.

The number of respondents in this study was very small because the industry was small. The main bulk of the people involved during its heyday have retired or essentially vanished, leaving only faint footprints behind in the words of their publications, and therefore while they were probably still alive, this brief period of history seems only able to give faint glimmers of information in the teased out meanings behind the official publications and newsletters to hint at directions the industry and regulatory body were pushing for. Government bulletins also were difficult to take wholly at face value, especially since there was little incentive for the regulatory body like the AVA to present anything less than the good aspects of their actions, policies and ideology. Furthermore, even papers such as the back issues of the *Singapore Journal of Primary Industries* and *Aquarama Conference Proceedings* were difficult to obtain. While Dr Ling Kai-Huat from AVA had very kindly allowed me access to scan these documents, older documents had very likely been thrown away to conserve space and prevent insect infestations. There were some articles, like most of another informant's own scientific publications which have essentially been lost because of this action, as there has been no separate and

complete repository of these articles anywhere else.

Attempting to reconstruct the history from what remains of the document sources was thus slightly difficult to reconcile with the oral interviews I had conducted. However, even with these limitations it is still possible to get a sense of the richness of the history of this industry, and how much it had been affected by other aspects of governing regulations. I hope that by using the various document sources, interviews and participant observation, I managed to show the complex relationships that people have and the multiplicity of roles that people and even institutional bodies can play in Singapore's ornamental aquaculture industry, even as small as it is.

I used document sources to build a qualitative history of the ornamental aquaculture industry of Singapore, and analysed the kinds of knowledge generated by the people working within aquaculture, prioritizing on ornamental fish aquaculture, but also including other kinds of aquaculture and agriculture, as ornamental fish aquaculture is a subset of these fields and are informed by the other larger industries. In order to define specific practices of aquaculture that generate knowledge, I performed an analysis of published literature, produced and consumed by people working in the aquaculture field. The groups of people included of scientists, farm owners, farm workers, hobbyists and government officials from the relevant statutory board in Singapore. These people, as I have found out, were not mutually exclusive or

discrete groups. Several individuals were capable of identifying within several of these categories, such as being both a farmer and a hobbyist, or a hobbyist and also government official.

Scientists, policy-makers, the farmers and hobbyists in Singapore were fairly literate groups. Hence much of the knowledge they generated would be in the form of journal articles, and other similar scientific literature by the scientists, papers generated by and for policy-makers. The hobbyists and farmers not only produced their own literature in the form of newsletters they also subscribed to koi breeding magazines and other such material for the consumption and development of their own practises of aquaculture in Singapore.

In order to build a qualitative history of the ornamental aquaculture industry, I used published papers as well as any other kind of literature produced by various groups. This was similar to how Hannah Landecker formulated the methodology in her book, *Culturing Life* where she countered the assumption that interviews and archived data reflect reality better than published papers by using scientific literature as a primary source to analyse scientific practices, paying particular attention to parts where people recorded how and what they did.¹⁰⁸ In this research, the subject was living koi, the "experimental systems" was the koi, reproducing and produced in a human controlled environment in both Singapore and Japan, and the KHV virus, that

¹⁰⁸ Landecker, *Culturing Life*, 23.

existed in a system with the koi. As this is a contemporary history of a currently evolving industry, interviews and observations of key persons in the industry were important, but just as important were the documents and journal articles that the people themselves wrote, and used, and referred back to as justification for their policies or practices. Books and manuals that were not published in Singapore by my study subjects but were instead used and referred to were also considered important primary document sources as they were considered to be sources of knowledge and practices that were meant to be emulated or modified in Singapore at the time. Over time, different manuals and other literature were preferred compared to others, and thereby painted a partial picture of how knowledge was translated from fish biology into fish husbandry practices and recommendations over time. Thus, the literature used by farmers and hobbyists in breeding carp or dealing with carp diseases and water environments in Singapore were also analysed. These included books such as *Kokugyo* translated from Japanese into English, and *Nishiki Mondo*.

Quantitative scientific literature was also necessary for the study of how people were translating scientific knowledge of KHV and other fish related knowledge into regulations and farm practices. As more knowledge of the virus was generated, for example, the regulations and farm practices in Singapore also changed. This scientific literature was critical for understanding the underpinnings of the actions taken by

government bodies with regard to koi aquaculture. Traditional sources of scientific literature from databases like Web of Science, JSTOR, CiNii and scientific literature generated by scientists working on aquaculture, on koi and related carp, as well as other fish species, with a focus on Singapore-based scientist and scientific institutes formed a part of the document sources that were used to build a background and knowledge generation that my study subjects were informed by. Some published literature used for Chapter 4 was focused mainly on the koi herpes virus and the investigation of the disease and pathogen. As the disease was shown to have international impact as well as having a strong impact on Japanese industries (as discussed in chapter 4), most of the primary sources for that chapter were international in nature, with a focus on Japanese sources, particularly from the *Bulletin of Japan Fisheries Research and Education Agency*. Unless indicated otherwise, these sources were originally written in English. During my fieldwork in Japan, a lot of the primary documents I collected were in older, scientific Japanese language that I had not had time to have translated. The primary sources I therefore used were scientific publications were also primarily published in English, omitting the Japanese-language documents for the moment. The data collected from Japan also included documents such as research reports from the Niigata Prefecture Inland Freshwater Fisheries Research Station and the Bulletin of Japan Fisheries Research and Education Agency, aquaculture manuals from the Kansai-kan of the

National Diet Library, and other published material sourced from databases such as CiNii.

The Agri-Food and Veterinary Authority of Singapore also produced publications in both industry and research areas. Examples of these were *Singapore Journal of Primary Industries* and the *Ornamental Fish Newsletter*. These will be used as document sources as well, as they provided insight into the direction of regulatory policy for the ornamental fish industry in Singapore, as well as situating the scientific understanding of the people working with these organisms in both an international milieu and uniquely localised context. All of these publications were publically available. At least two of my informants were active AVA officials and would only refer me to publically available information. Official statements from the AVA thus had to be gleaned from the documentations that are publically available such as *AVA Visions* and other material. Hard copies of memos and other potentially informative data were not possible to elicit from the officials I had talked to, as they were wary of letting potentially sensitive information leak out to a non-colleague, they claimed that past memos were out of date and thus not allowed to be shown to the public. I therefore had to conservatively extrapolate the government's intentions from the publically available material.

The qualitative methods outlined above provided a way to understand the change in koi cultivation over time. Koi cultivation also

would be different across space, hence I travelled to Niigata, Japan to also observe cultivation practices in Japan. I used document sources to infer different practices, but in this case compared practices and policy effects between health, food agriculture and ornamental aquaculture in Singapore, as I had discovered food agriculture was governed closely by human disease regulation. I discussed the results of the disease regulation in Chapter 4, where I detail the relationships between human health regulation, human food regulation and ornamental fish regulation. Particularly important for this comparison had been literature generated for the use of policy making such as knowledge incorporated into government literature, which in turn directly changed regulatory practices of ornamental fish aquaculture and thus the practices on farms.

1.8 Organization

Koi currently exists in various spaces within the aquaculture industry of Singapore. The physical spaces within which they exist are critical to the way people interact with them. I decided to preface most of the chapters by writing a vignette that I felt was representative of each topic, and that encapsulates a particular part of the chapter's topic. The use of vignettes is common especially in anthropological and sociological studies. Some scholars used vignettes to make a subject or concept personal; others used the vignette to dwell on an object and thus its position in the larger concept that they are trying to elucidate,

and for the most part, "can elicit perceptions, opinions, beliefs and attitudes from responses or comments to stories depicting scenarios and situations¹⁰⁹". I used vignettes to allow "interpretation of actions and occurrences that allows situational context to be explored and influential variables to be elucidated", which was an application of Rhidian Hughes' interpretation and implementation of the vignette in his work.¹¹⁰ In my case, the vignettes were representative of places: where the actions of government action played out (Chapter 5), the physical location where the industry manifested (Chapter 3) and in places where the topic was of most concern to the actors (Chapter 4). The vignettes also laid out the sites of importance in this industry: the farm, the conference, and the hobbyists' homes, and were mainly thick descriptions of these sites and the people working within them. These were not only places of importance to the industry, but these places were also connected by the people involved and by the koi carp themselves. Koi existed in all of these spaces, physically or metaphorically, and this spatial connection laced and forced people to interact and be connected. The people self-identified based on this connection, and were drawn to spaces such as the Aquarama, an ornamental fish and accessories exposition and conference, or the farm because of the koi. A scientist might look at koi and see the puzzle of a

¹⁰⁹ Christine Barter and Emma Renold, "The Use of Vignettes in Qualitative Research," *Social Research Update: Department of Sociology, University of Surrey*, no. 25 (1999)

¹¹⁰ Rhidian Hughes, "Considering the Vignette Technique and Its Application to a Study of Drug Injecting and HIV Risk and Safer Behaviour," *Sociology of Health & Illness* 20, no. 3 (1 May 1998): 381-400.

temperate fish surviving and living in a tropical climate far removed from its original habitat and climate. But the koi is more than its DNA and its evolutionary niche; its colours and patterns and its very survival in Singapore required a receptive social, political and economic climate.

In this thesis I answered the question of how the history of ornamental fish aquaculture influenced koi aquaculture in Singapore and both in turn were influenced by biosecurity concepts enforced in the wake of a koi specific disease that occurred in 2006. My study was an attempt to answer these questions: First, how and why did ornamental aquaculture practices in Singapore change over time? Second, what did Singapore take from Japan's koi cultivation practices, and how did they change them? Finally, what kind of knowledge is derived from koi aquaculture? I answered these questions by analysing the kind of knowledge that emerged from the translocation of koi and the translation of this knowledge into Singapore farm and husbandry practices, government policy and regulations. To this end, the organization of this thesis is meant to show how motivation was critical to the kind of knowledge required, and then the subsequent translation of said knowledge into aquaculture practice. The translation of knowledge is critical to the successful translocation of koi from Japan to Singapore, and the organization of the chapters will show the flow of the translocation process as I analyse the history of koi aquaculture in Singapore.

In this chapter, I outlined the frameworks of how animals and humans related to each other, and how scientific knowledge is generated from koi aquaculture in Singapore. I explained the analytical lenses of translation and translocation that I used, and how they were pertinent in understanding the history of ornamental fish aquaculture, translocated koi disease and how they informed the changes in aquaculture practices in the emergent theme of biosecurity.

In analysing the history of ornamental aquaculture in Singapore, I first had to lay the groundwork of the state of water and land limitations in Singapore. A history of aquaculture in Singapore must be written with the context of land and water limitations in mind. In Chapter 2, I will discuss how limited land available for agriculture and limited freshwater affects affected ornamental aquaculture and resulted in their competing with other needs of the Singapore state. As a result, ornamental fish aquaculture focused on closed-water systems and became relevant space in which to discuss translation and translocation, because the scientific understanding of water quality and how it affected and related to fish health was prioritized by researchers in the government and academia in Singapore. I will show how water quality became associated with koi quality beyond its aesthetics, and also became the space through which government could intervene in, in the years presaging the enactment of biosecurity regulations.

In Chapter 3 I will discuss the beginnings of ornamental fish aquaculture from the earliest modern records of Singapore's history prior to 1965 till the present (2018). I will analyse the political relationship of Japan and Singapore, and how it on the ornamental fish industry in general and koi aquaculture in particular. The history of government decision on ornamental aquaculture makes sense within the context of limited water and land in Singapore. I will discuss the socio-political context against which koi and their healthy status became linked to Singapore's reputation and identity. I also will analyse the rise and decline of the koi aquaculture industry in Singapore from 1965 till the present, pinpointing the emergence of a highly lethal koi-specific disease, the Koi Herpes Virus (KHV), as the start of the decline of the ornamental fish industry in Singapore. The biosecurity regulations taken to prevent its presence in Singapore were considered by both Singaporean farmers and hobbyists to be the cause of the decline of the koi industry in Singapore. I will use this history of the ornamental fish aquaculture to show the historical and social context of the translocation of koi to Singapore, and how these contexts allowed for human attempts to recreate the Japanese environment in Singapore's koi aquaculture practices.

In Chapter 4 I will trace the origins of KHV from its first detection and characterisation in the US and Israel to its reveal its impact on Japan. I will examine how the biological properties of the

virus and its relationship with the fish were made legible by international groups of scientists as an external harmful agent. As Japan was and is the global breeder and supplier of koi, the scientific knowledge of KHV was translated into actionable regulations to deal with KHV and prevent its entrance to Japan and spread. In addition, I will show that Japan's reaction in dealing with the KHV was by implementing disease management regulations and developing a protocol to deal specifically with KHV, and their impact on the Japanese koi industry was influenced by and influenced other countries' policies on importing and preventing the spread of KHV within their boundaries. The Japanese government officials and their interaction with Japanese farmers and hobbyists were also analysed to understand how the disease management protocol in Japan influenced farming practices.

In Chapter 5, I will analyse the policies that the Singapore government enacted in order to control and limit the spread of KHV in Singapore, showing how they developed from the protocols developed for dealing with diseases. The scientific knowledge of KHV had been translated into a concept of a militarized infectious agent in Chapter 4, and now Singapore's regulations were influenced by biosecurity protocols used in dealing with other disease threats such as avian flu and 2003's SARS. I will show how the disease management protocol for managing KHV from Japan was translated into fit into Singapore's

biosecurity rhetoric. I also will analyse other factors such as the Singapore government's shift of focus away from ornamental fish and towards other industries. The shift in focus led to a somewhat more acrimonious relationship between government officials and farmers, who were no longer able to find government support for maintaining their farms as well as hobbyists who both found the importing requirements for koi much more restrictive post-KHV, and the government policies which do not apparently take into account the relationship between KHV and fish and human activity in the Singapore context.

I will conclude in Chapter 6 with how disease management impacted koi aquaculture and ornamental fish trade. I will show how KHV emerged as a biosecurity issue from of the translation of translocated fish and its relationship with its environment into aquaculture husbandry practices. In translating disease into a militarized external threat, KHV was translated into a biosecurity issue and thus required biosecurity regulations and these regulations had a strong negative impact on the koi industry and the ornamental fish industry of Singapore as a whole.

Chapter 2: Good water is good koi: The association of water with koi health (1965 to 2004)

In this chapter, I briefly examined how the historical knowledge of fish's relationship with water was understood in aquaria since the 1800s and how this history laid the foundation on which current understanding of water and its various qualities influenced ornamental fish and koi aquaculture in Singapore. The drive to understand water and how it affected fish health resulted in the translation of the aquatic environment into water characteristics by scientists. The development of scientific understanding of water quality first resulted in the refinement of water parameters and how it related to fish health, and finally how these parameters could be manipulated to achieve results in fish health, particularly in ornamental fish. Water parameters are defined as various chemical, physical, and biological characteristics of water.¹¹¹ The measurement of these can characterise any particular body of water relative to the requirements of a species. For example, the oxygen content in any body of water indicates whether fish can survive in it. Every group of people involved in koi aquaculture developed an understanding of these water characteristics particularly pertaining to ornamental fish and translated them into factors they could manipulate to exert control over the koi's living environment and health. Due to

¹¹¹ Donald L. Johnson et al., "Meanings of Environmental Terms," *Journal of Environmental Quality* 26, no. 3 (1997): 581-589.

limited water supply for aquaculture, much of the focus in water for aquaculture purposes turned to development and use of closed-water systems in Singapore from 1989 onwards on both farms and in hobbyists' homes. This heightened the necessity of translating water parameters into factors that humans could control, and at the same time opened a space in which the government could intervene with regulations. One of the most important water parameters that were of concern to people in fish farms and hobbyists was the presence of disease pathogens in water. Unlike most parameters such as oxygen or nitrogen content, presence of some disease pathogens such as KHV were not always directly measurable or observed, and could only be detected in the bodies of the koi themselves. As the transmission of such diseases usually is via contact with water that had housed infected fish, water itself became used as a proxy to measure disease. Water quality also became associated with quality of koi, which meant that water quality became a space that the government could intervene, setting the stage through which the government would subsequently be able to enact biosecurity measures.

This analysis is necessary in order to highlight the importance of human manipulation of water parameters to maintain fish health, and how the contemporary understanding of particular water parameters and how fish contract water-borne disease through inhaling and living in water opens up the industry to implementation of disease

management in the form of biosecurity. A historical account in this chapter of how limited water resources came to be entangled and meaningful in various social groups such as scientists, fish hobbyists and to state officials, lays the groundwork for the subsequent chapter on the history of the ornamental fish industry. This historical analysis analyses how the development of water circulatory systems and associated scientific knowledge in fish aquaculture created spaces through which the government could act, and presages the enactment of biosecurity. There are several groups of people involved in the aquaculture industry in Singapore. To keep track of these groups and make the analysis of their actions meaningful, I have roughly divided the industry players into Regulation Officers, Scientists, Farmers and Hobbyists based on their roles and activities within the ornamental fish industry. These roles are not necessarily firm. Many of the farmers were originally hobbyists, some of the regulation officers were scientists, or hobbyists. The divisions are useful in conceptualising the kinds of activities that are performed within the aquaculture industry, however, and help contextualise the complicated relationships that they have with each other. The translation of understanding water into scientific understanding allowed humans to gain control of water quality and its parameters and ultimately fish health.

2.1 Water science: the scientific roots of hobbyist aquaria.

The scientific knowledge that Singapore koi farmers and hobbyists have about water quality and how they pertain to fish have their roots in the late 19th century Europe. These scientists and naturalists started the listing of qualities of water that current Singapore aquaculture had expanded upon and still utilizes. Since the late 19th century, aquarium owners already knew that the basic properties of aquarium water had to be monitored, or at least carefully maintained,¹¹² with aquarist Philip Henry Gosse cautioning readers in 1856 who wished to keep fish at home to be careful in obtaining and conveying water, though he was not sure what particular chemical may cause defects in the water quality. In 1858, Henry Butler wrote in his book *The Family Aquarium* extolling the virtues of keeping ornamental fish in aquariums, but instructing readers that "water in the tank, it is hardly necessary to say, because the intelligent reader will presume it to be obvious, should be of good quality"¹¹³, where he mentions that neither "water impregnated with iron and certain salts" nor boiled water is suitable, since boiling water "expels too much of the oxygen, the presence of which is absolutely necessary to sustain aquatic life." During this time, researchers would only monitor oxygen levels and visible

¹¹² Philip Henry Gosse, *The Aquarium: An Unveiling of the Wonders of the Deep Sea* (J. Van Voorst, 1856).

¹¹³ Henry D. Butler, *The Family Aquarium, Or, Aqua Vivarium: A New Pleasure for the Domestic Circle: Being a Familiar and Complete Instructor Upon the Subject of the Construction, Fitting-Up, Stocking, and Maintenance of the Fluvial and Marine Aquaria Or River and Ocean Gardens* (New York: Dick & Fitzgerald, 1858).

qualities of the water, such as colour, taste and smell, and the water sources, acknowledging that what was healthy for human consumption was not so for aquatic fish, primarily fish.

In 1889, an author in the *Naturwissenschaftliche Wochenschrift* (Natural Science Weekly) stated the practice of importing salt water for marine aquariums left much to be desired as the importing of the water usually had it arrive pungent and unusable for aquariums. Instead, preparation of artificial salt water could be done with various salts,¹¹⁴ which was a sign of a better understanding of the various salts and chemicals in what constituted salt water. Freshwater, on the other hand, was much more convenient and did not require such preparation for amateur fish keepers. The subsequent shift to mainly freshwater aquariums was due to convenience. Also by this time period, rare colourful fish were starting to become available in Europe, and by 1891, the aquarium started to occupy a space between "hobby scientist and private society"¹¹⁵. A certain scientific knowledge and understanding of the water quality was necessary in order to maintain fish successfully in an aquarium. While not tropical, koi and goldfish were freshwater colourful fish, and they became one of the fish kept in aquariums and ponds in the middle of this understanding.

¹¹⁴ Brunner, *The Ocean at Home*, 68.

¹¹⁵ Daum, Andreas W. *Wissenschaftspopularisierung im 19. Jahrhundert*. Munich: Oldenbourg, 1998.

Over time, the aquarium also became an object for non-scientists to keep. By 1933, aquarium keeping had become a hobby that warranted manuals for non-scientists who just wanted to keep fish, and not necessarily for scientific experimentation. For example, in *The Cult of the Goldfish* by Theodore Roughley, he explained disease treatment in simple but authoritative language such as claiming "the most effective treatment for killing the parasite in all stages, including when it is on the fish, consists of the use of heat" for goldfish with a caveat cautioning not to heat water too much because at high temperatures "a considerable amount [of oxygen] is driven out of the water, for the higher the temperature the less oxygen the water will hold."¹¹⁶ The understanding of water properties and its relationship with oxygen was clear enough at this point to be written in a simple fashion as advice to the lay-hobbyist. Waterborne diseases were also introduced as a water parameter that could be manipulated. When disease appeared in an aquarium, "great care must be taken to see that it is not introduced into the others", and that "anything introduced to the water should be thoroughly sterilized before they are allowed to come in contact with the water in the other aquaria."¹¹⁷ This understanding of waterborne disease and the method prevention of its transmission continued to form the basis for disease prevention in koi cultivation practices.

¹¹⁶ Roughley, Theodore Cleveland. *The Cult of the Goldfish*. (1933), 134.

¹¹⁷ Roughley, *The Cult of the Goldfish*. (1933), 135.

2.2 Water as a resource for the Nation-State of Singapore

Limited water availability drove the scientific motivation in water science. Water has historically played a large role in state politics and trade in Singapore's history. Heather Sutherland wrote that Southeast Asia's development grew from European trade,¹¹⁸ which was facilitated by the connectedness of water in the region. While Sutherland and others have criticized the use of modern states in the determination of historiography of the region,¹¹⁹ a contemporary history of Singapore's relationship with water and its neighbours is determined by the behaviour of the governing body's reaction to contemporary statelines, and it is simpler to examine Singapore's relationships with water in the sphere that it can control. The resulting historiography resorting to using 'hybridity'¹²⁰ was also criticized by Sutherland, in that it is also problematic "as the focus on accommodation and blending presupposes the existence of clearly defined entities."¹²¹ Singapore's

¹¹⁸ Sutherland, "Geography as Destiny?," *A World of Water: Rains, Rivers and Seas in Southeast Asian Histories*, 2007, 27–69; Victor Lieberman, "An Age of Commerce in Southeast Asia? Problems of Regional Coherence – A Review Article," *The Journal of Asian Studies* 54, no. 03 (1995): 796–807. Sutherland was responding to Victor Lieberman's statement that foreign trade formed the growing bulk of growth in Southeast Asia in the 17th to 18th century. Victor Lieberman, "An Age of Commerce in Southeast Asia? Problems of Regional Coherence – A Review Article," *The Journal of Asian Studies* 54, no. 03 (1995): 796–807.

¹¹⁹ Craig J. Reynolds, "A New Look at Old Southeast Asia," *The Journal of Asian Studies* 54, no. 02 (1995): 419–446; Sanjay Subrahmanyam, "Connected Histories: Notes towards a Reconfiguration of Early Modern Eurasia," *Modern Asian Studies* 31, no. 03 (1997): 735–762; Heather Sutherland, "Geography as Destiny?," *A World of Water: Rains, Rivers and Seas in Southeast Asian Histories*, 2007, 27–69.

¹²⁰ Oliver William Wolters, *History, Culture, and Region in Southeast Asian Perspectives*, 26 (SEAP Publications, 1999); Heather Sutherland, "Trade, Court, and Company: Makassar in the Late Seventeenth and Early Eighteenth Centuries," *Hof En Handel: Aziatische Vorsten En de VOC*, 2005, 1620–1720.

¹²¹ Sutherland, "Geography as Destiny?" 30.

statehood is recent, having only been independent of Malaya in 1965, and thus use of the 'hybridity' concept in analysing Singapore is difficult, even though a large part of Singapore's aquatic related trade is international and very little to do with domestic markets. Charles Tilly's (1990) argument that development of early modern Europe states were driven by competitive pressures of "coercion and capital"¹²² and is somewhat simplistic because it ignores the historically international roots of Singapore's ornamental fish industry. Instead, Sutherland's argument about "commodity flows that brought people, ideas and technology, money, crops and firearms, that changed the region"¹²³ is certainly true in that Singapore's 'open' attitude to trade and technology allowed the sharing of scientific knowledge and practices how to manage water in the ornamental fish industry.

There are arguments that water pollution was not a major problem in Southeast Asia prior to the 1970s, but Brenda Yeoh argued that local waste products of the big cities did cause very dirty water prior to that date¹²⁴, and the treatment of pig farms in the late 1960s in Singapore puts that argument in perspective. It was not large cities but specifically local small pig farms that were feared to produce polluted waters. Even as late as the 1980s, officials were examining the water pollution issues in swine farming; and pushed for a reduction of pig

¹²² Charles Tilly, *Coercion, Capital, and European States, AD 990-1992* (Blackwell Oxford, 1992), 5.

¹²³ Peter Boomgaard, "In a state of Flux?" in *A World of Water: Rains, Rivers and Seas in Southeast Asian Histories*, ed. Peter Boomgaard (Leiden: KITLV Press, 2007), 4.

¹²⁴ Brenda SA Yeoh, "Urban Sanitation, Health and Water Supply in Late Nineteenth and Early Twentieth Century Colonial Singapore", *South East Asia Research* 1, no. 2 (1993): 143-172.

farming overall in Singapore. Industrial wastewater was not a huge concern in the early years of Singapore's independence. From the government's perspective, water was important in terms of providing for the population survival. Agriculture, of which koi aquaculture is a part, polluted water, pitting aquaculture against fresh water needs for state survival.

Water has been a concern for the Singapore state, especially since its independence from the British Empire and Malaya. Singapore and Malaysia had signed four agreements to regulate water supply from Malaysia to Singapore, two of which are currently in force. The one that had expired most recently, in 2011, had raised issues with contemporary audiences in their worry about Malaysia withholding water from Singapore and whether current actions with Singapore's reservoirs, waste water recycling and desalination treatments were enough to cope with the loss, even if Malaysia were to refuse to continue honouring the remaining two agreements. Part of the effort of reducing Singapore's reliance on external water sources include actions taken during the years just after independence in 1965, Singapore's PPD started working with PUB (the Public Utilities Board) and HDB (Housing Development Board) to expropriate farmland for non-agricultural use. It started to push for agriculture to be performed off-shore or even in overseas.¹²⁵ While main drive behind this action was the shortage of land in

¹²⁵ Rodolphe de Koninck, Julie Drolet, and Marc Girard, *Singapore: An Atlas of Perpetual Territorial Transformation* (Singapore: NUS Press, 2008), 40.

Singapore's mainland island, as I had mentioned earlier, agriculture was considered water polluting. Pig-farming was considered to be extremely polluting in its waste water production. "Although needing little local space, pig farms were reduced and eliminated, primarily for ecological reasons, most notably water pollution,"¹²⁶ showing that the Singapore state prioritised clean water over local food production at this time.

While other kinds of agriculture were not considered to pollute water as much, they too were reduced, including freshwater aquaculture. As the state needed water to be clean and disease-free, it therefore had reason and motive to need to intervene on water quality in aquaculture settings.

Since maintaining good water quality was important in order to keep aquaculture farms running, the drive of the science into Singapore's aquaculture industry then turned towards ways of minimizing the polluting impact aquaculture waste had on water in general. One such possible method was investigating ways of manipulating the fish and feed, in order to maintain water quality without compromising the fish's health. For example, in 1982, Professor Shim Kim Fah and colleague from National University of Singapore investigated the feed conversion and nutritional health of guppies based on diets.¹²⁷ Part of the methodology of his experiment involved keeping

¹²⁶ Rodolphe de Koninck, Julie Drolet, and Marc Girard, "Singapore: An Atlas of Perpetual Territorial Transformation' (Singapore: NUS Press, 2008), 40.

¹²⁷ K. F Shim and J. R. Bajrai, "Growth Rates and Feed Conversion in Young Guppy (*Poecilia Reticulata* Peters) Fed on Artificial and Natural Foods," *Singapore Journal of Primary Industries* 10, no. 1 (1982): 26-38.

the tanks "cleaned" by removing faeces and water from the bottom of the tanks, and salinity was maintained with the topping up with "standing tap water", and "adequate aeration" with minimum variations in pH and temperature. These kinds of methodology in scientific experiments were considered standard by 1980s that there was no comment on these actions. However this was not the most useful way to maintain water quality, since fish waste and water quality had to be maintained manually.

Instead, the main avenue of research that enhanced water quality and reduced the polluting impact of aquaculture was by investigating recycling systems. These were systems that allowed the same volume of water to be used within a facility instead of having to constantly discard large volumes of used and polluted water and bring in fresh water. Researchers in the PPD were collaborating with the scientists in NUS on water recycling systems for industrial purposes by 1982. The justification was because "freshwater bodies in Singapore are limiting and not readily available for aquaculture,"¹²⁸ not only stating the importance of the ornamental and freshwater aquaculture was to Singapore but also explicitly stating that the tested freshwater recycle system was "water quality parameters were well within the acceptable ranges for fish culture." These parameters were therefore used in conjunction with fish growth as a tool to judge how appropriate a water

¹²⁸ Wah Chang Lam, "Studies of a Freshwater Recycle System Using *Leptobarbus Hoevenii* (Ikan Jelawat) as a Test Species," *Singapore Journal of Primary Industries* 10, no. 1 (1982): 1-18.

filtration or similar system was for rearing fish in freshwater conditions. These parameters, such as nitrogeneous chemical levels, after passing through the system over a specified time period eventually became indicative of water quality.

Singapore's PPD and scientists considered several water parameters to be critical for all aquatic life. At the same time closed-water systems were being investigated, the PPD published a oceanographic survey of the hydrological conditions in the East Johore Strait that they had conducted in 1977, examining temperature and salinity of the region to determine how suitable it was for fishery species and the possibility for marine aquaculture (aka mariculture),¹²⁹ thus exhibiting the fact that scientists, researchers and officials were all in agreement that these factors were critical for all aquatic life, depending on the species. It was also not just the fish's environment that researchers were concerned about. The fish also had to be fed, and food sources for fish, whether for food or ornamental purposes was reared or cultivated in the water, leaving the water's characteristics an additional layer of importance.¹³⁰ The PPD and Singapore based scientists were trying to investigate expanding areas suitable for cultivation of fish for both inland and marine purposes, and they were using the tools they understood about water parameters that were necessary for fish life, and

¹²⁹ L. C. Lim, "Coastal Fisheries Oceanographic Studies in Johore Strait, Singapore II Hydrological Conditions in the East Johore Strait," *Singapore Journal of Primary Industries* 12, no. 1 (1984): 17-39.

¹³⁰ K. H. Ling, "The Relationship between Growth of *Isochrysis Galeana* and the Salinity of the Culture Media," *Singapore Journal of Primary Industries* 14, no. 1 (1986): 19-26.

ultimately, trying to manage these parameters to gain control over fish health and quality.

2.2.1 Managing waterborne diseases in the Aquaculture Industry

Over time, the understanding of water parameters have been expanded upon. While the number and detail of water parameters have increased since the nineteenth and twentieth centuries, the aim in manipulating these water parameters have remained the same up till the present: to maintain fish health. As a result, the measurement of disease-causing microbes gained importance in the aquaculture industry.

Unhealthy fish display a variety of symptoms, some of which can be corrected or prevented by maintaining certain levels of water parameters. For example, a fish gasping at the water surface indicates that the water is low in oxygen and the correction would be to aerate the water. On the other hand, other symptoms can be caused by disease-causing pathogens, rather than physical or chemical water parameters. An example would be skin lesions which can be caused by bacterial infections. Fish diseases can be genetic or caused by external agents. While the exclusion of a genetically unhealthy fish is easy enough, external agents that cause disease do not all stay in the fish's body.

Water-borne diseases are a particular concern in aquaculture. Parasites can be removed with mechanical filters and medication, but the invisible pathogens at the microbial level are harder to remove. Bacteria and viruses can remain in the water column even if the visibly

diseased fish were removed. Microbial pathogens are considered one of the main pollutants of aquaculture waste¹³¹ and disastrous in a farm if not controlled. Further elaborating the invisibility of agents within the water that people agree that can affect fish, is the invisible disease-causing microbes in the water.

Due to the small microscopic nature of the microbes, water in turn becomes a proxy for the disease itself, since "moving aquatic organisms from one farm to another may, via the water used for transport, bring new microorganisms to the recipient farm" and thus "treatment of the effluent water is absolutely necessary in such cases."¹³² As testing for particular microbes is far too expensive for the normal fish hobbyist, treating the water routinely is much more cost-effective. Instead, the water becomes 'diseased', and must be removed, with the sick fish being isolated away from the rest of the pond or aquarium, so that it can stop contaminating the water surrounding it.

Government officials considered the isolation of the fish and their water as equivalent with the isolation and prevention of disease spreading, and a particular emphasis on "proper drainage system for discharge of water directly into the sewer system" in addition to strict handling protocols were necessary to "ensure that the ornamental fish export trade in Singapore would be able to keep up with future

¹³¹ Odd-Ivar Lekang, "Water Quality and Water Treatment: An Introduction," in *Aquaculture Engineering* (John Wiley & Sons, 2008), 32-36.

¹³² Lekang, "Water Quality and Water Treatment," 34.

developments in the quarantine regulations of importing countries."¹³³

A large portion of the ornamental fish trade thus became tied up with import and export.

Singapore acted as a transit destination for ornamental fish as well. Dealers would source and import fish from all over the Asian region, such as from Malaysia, China and Japan, and export them after sorting to other countries, particularly the UK, US and Europe.¹³⁴ The transitioning role that Singapore played became part of the way Singapore was adding value to the imports and giving the exported fish part of Singapore's identity. Disease was also strongly associated with the external, and the perniciousness of disease meant that water that fish arrived in was suspect, requiring treatment and removal from the fish that were brought in, in addition to having to be isolated from the already present fish. This externalised, foreign view of disease is highly important to the way disease management protocols were formulated and implemented by Singapore's regulatory officers on koi. How this association of external disease to water intersects in the space of koi aquaculture and informs disease management regulations in Singapore will be elaborated in Chapter 5. The association of disease with a fish's water did not apply only to fish in farms, but also to fish personally owned by private individuals. The practice of isolation and quarantine

¹³³ Ling K. H., Lim L. C. and Cheong L., "Quality Enhancement of guppies for export: Eradication of parasites," *Singapore Journal of Primary Industries* 24 (1996), pg 43-50.

¹³⁴ Agri-food and Veterinary Authority of Singapore (AVA), "Singapore plays host to AQUARAMA 2007," in *AVA Vision* 2007, issue 2, 9.

is still practiced in by contemporary hobbyists. When one buys a fish, whether it be goldfish, guppies or koi, the owner is advised to first quarantine the fish. With koi, the koi has been isolated or quarantined on farms when it was first imported, so the chance of disease brought from outside of Singapore is assumed to have been eliminated. On bringing the fish home, however, acclimation of the fish is required; that is, not putting the fish directly into its new tank environment but instead floating the bag of fish in the tank to allow the temperature to even out between the bag the fish is in, and the tank. Then water from the tank is added to the bag in small increments to allow the fish to get used to the difference in pH and hardness and other invisible properties of water between the tank water and the bag water.

For many fish owners whose fish died, the cause can be attributed to a disease transmitted by the water, or from the fish's reaction to the water's properties.¹³⁵ Ultimately, many cases of a fish's ill health or death can be traced to the water. As this concept is common and reproduced in many fish manuals in the past and in contemporary koi manuals, such as *Nishikigoi mondo*, this led to many koi hobbyists' present obsession with water quality.

Water quality management was so critical to Singapore's ornamental aquaria industry that the first Aquarama held in Singapore, 1989, had an entire panel devoted to the water management in

¹³⁵ Shuji Fujita, *Nishikigoi Mondo*, ed. Mark Gardner and Kiyoko Tashiro, trans. Aika Watanabe, English Edition (Tokyo, Japan: NABA Corporation, 2009), 283.

ornamental aquaria. That included the examination of water filtration systems in public aquariums such as in PPD's Dr Ling Kai-huat's paper on the management of the Van Kleef Aquarium, where Dr Ling writes about the filtration system incorporating rainwater for recycling into the water system.¹³⁶ With volume of water already considered an important factor in establishing a farm, public aquariums (and thus, farms) have also taken the idea of a fixed volume to heart in their design of management and thus recycling mechanisms and systems had become the de-facto part of managing water in their systems, eliminating the issue of requiring a constant supply of large volumes of water. Dr Ling's paper further included a section of not only the water filtration and recirculation system of the aquarium, but also a section where control of the water quality is important, and involved constant monitoring of by the staff of "pH value, chlorine content, oxygen saturation, carbon dioxide content, ammonical nitrogen, nitrite nitrogen, nitrate nitrogen, and heavy metal content such as calcium, iron and lead," and that "if the water quality is unfavourable, corrective measures include water changes and strong filtration" without the use of drugs or chemicals because of the fear of "upset[ting] the natural environment of the system."¹³⁷ At this point in 1989, the importance of water in the

¹³⁶ Ling Kai Huat, "Public Aquarium Management: A Case Study of the Van Kleef Aquarium", edited by John Dawes, *International Aquarium Fish and Accessories Conference*, Aquarama Proceedings: First International Aquarium Fish and Accessories Conference (Singapore: Academic Associates, 1991), 114.

¹³⁷ Kai Huat Ling, "Public Aquarium Management: A Case Study of the Van Kleef Aquarium," in *Aquarama Proceedings: First International Aquarium Fish and Accessories Conference*, vol. 1

ornamental aquaculture was so high that the science involved was fairly sophisticated, compared to earlier understandings of water parameters.

As a result of the very detailed understandings of water parameters by the beginning of the 1990s, koi keeping manuals¹³⁸ devote complete sections to the water. For example, in a koi keeping manual professed to contain a complete run-down of the information required to keep koi, published in 1995¹³⁹ had an entire section on water quality and analysis, but two other chapters, one on the types of filtrations and filters needed in a koi pond and another chapter on pond cleaning relate directly to the maintenance of water in the pond.

The presence of water in all these manuals were a signal to even contemporary farmers and officials on how necessary water management was in aquaculture. Even early as in the 1980s, officials from the Freshwater Section of the PPD like George Tay consulted manuals like those written by a respected koi keeper, and manuals like *Koi Varieties* opened the section on tips for keeping koi with a few sentences praising koi's ability to thrive in water situations that were not

(Aquarama: First international Aquarium Fish And Accessories Conference, Singapore, 1989), 114-18.

¹³⁸ Examples of koi keeping manuals include George C. Blasiola, *Koi: Everything about Selection, Care, Nutrition, Diseases, Breeding, Pond Design and Maintenance, and Ponds* (Hauppauge, NY: Barron's Educational Series, 1995); Herbert R. Axelrod, *Koi Varieties: Japanese Colored Carp-Nishikigoi* (T.F.H. Publications, 1988); Shuji Fujita, "Chapter 9: Fish Diseases That Affect Nishikigoi," in *Nishikigoi Mondo*, ed. Mark Gardner and Kiyoko Tashiro, trans. Aika Watanabe, English Edition (Tokyo, Japan: NABA Corporation, 2009), 220-80; M. Kodama, S. Fujita, and A. Kawabata, *Kokugyo* (Shin Nippon Kyoiku Tosho Company, Limited, 2002). These manuals had devoted at least one complete chapter on water management.

¹³⁹ George C. Blasiola, *Koi: Everything about Selection, Care, Nutrition, Diseases, Breeding, Pond Design and Maintenance* (Hauppauge, NY: Barron's Educational Series, 1995).

outright polluted. The author of this manual later mentions how he keeps koi in winter and summer, and how he had wanted to "take water from my roof and change the water in the pond every time it rains, but I found that the pollution settling on my roof and the acid rain were detrimental."¹⁴⁰ With water being so critical for maintaining koi health, water quality became associated with koi health.

2.2.2 The Diseased State of Water in koi aquaculture

As I had mentioned earlier in this chapter, water was already understood amongst hobbyists, farmers and regulatory officers since the early 1930s to be a medium of disease transmission. This was learned from experience on Singaporean fish farms, and in the form of fish manuals that hobbyists, farmers and regulatory officials used and referred to. The understanding that good water meant good fish did not change over time. Contemporary understanding of water in aquaria has linked fish's health to good quality water. Singapore hobbyists also learned this via experience and from other more experienced hobbyists or farmers.

The hobbyists and farmers above all were trying to maintain their koi's good appearances, and thus their health. Good health was therefore equated with water parameters in a good range. That is, various measurable qualities such as temperature, pH and oxygen levels of water. When the water parameters dip outside of this range, both

¹⁴⁰ Herbert R. Axelrod, *Koi Varieties: Japanese Colored Carp-Nishikigoi* (T.F.H. Publications, 1988), 61.

hobbyists and farmers consider the risk of disease to increase. For example, Jerome stated that warmer water meant that koi were more prone to disease. Too low a salt concentration left koi susceptible to parasitic infections. The constant changing levels of water in a pond (loss due to evaporation, addition from rainfall) meant that these water parameters needed constant monitoring and manipulating of the water parameters to maintain fish health.

Besides the changing water volume, the addition of organic material in the form of food also affected other water parameters. The koi are fed koi food, usually specially formulated koi food such as Hikari brand koi food, which can have different nutrition levels depending on whether the owner is trying to encourage growth (high in protein), or increase the colour of the koi (high in carotenoids). As all fish do, however, koi produce nitrogenous waste from their gills. This is equivalent to humans excreting urine. These nitrogenous wastes at high levels could burn the koi's gills and skin, in addition to raising bacteria populations. At the farm level, fish produced much larger volumes of waste and correspondingly, large volumes of fish wastewater need to be treated, regardless of whether this water would be reused or be discarded into environmental bodies of water (for example lakes or seas). Fish waste water primarily contain nutrients, organic matter and micro-organisms.¹⁴¹ These have a large ecological impact on the environment

¹⁴¹ Odd-Ivar Lekang, "Water Quality and Water Treatment: An Introduction," in *Aquaculture Engineering* (John Wiley & Sons, 2008), 32-36.

and can cause huge algal growths or introduce non-native species into the surroundings. The ornamental fish farm was an inherently polluting enterprise, where the fish required fresh clean water and by the very act of living polluted this same water, as well as passed diseases into it. The pollutive nature of fish farming thus necessitated a high level of human control, opening a space for potential government intervention.

2.3 Contemporary Water management practices in Singapore Ornamental Fish Farms

For scientific uses and aquaculture uses, a lot of the Singapore's contemporary ornamental fish aquaculture systems fall under land-based freshwater aquaculture, whose water parameters are considered easier to control marine aquaculture,¹⁴² especially since the volume of water tends to be fixed. Concentration of various chemicals in the water can be more readily manipulated by farmers. Since water sources of particular qualities meant for fish rearing and maintenance is limited, both Singaporean farmers and hobbyists tend to utilize a closed system of water-recycling or water reuse as a strategy to maintain the life of their fish. Fish farmers like Pay had to change his fish species on his farms as he moved from Sembawang in 1975 (rearing guppies) to Old Chua Chu Kang in 1983 (rearing goldfish) and to Jalan Lekar (rearing koi) as the quality of the water sources available changed as he moved

¹⁴² Odd-Ivar Lekang, "Water Quality and Water Treatment: An Introduction," in *Aquaculture Engineering*, Second (West Sussex, UK: John Wiley & Sons, 2008), 32.

geographically. The closed-water system allowed water reuse and minimized the use of large volumes of water of already limited sources. The invisible characteristics of water then becomes ever more important to the fish keeper, determining not just health but also even what kind of fish can be kept.

While Singapore has a high annual rainfall due to being in the wet tropics, much of the rain is not usable directly. Fish ponds in farms are built under a shelter, both in an attempt to keep predatory birds out and also to prevent rainfall from affecting the salinity of the water in the ponds, as well as the pH. Water-flow was also considered very important. Ornamental aquaculture industry players considered that after labour costs, water quality was of top importance: "obtaining water all year round of reasonably constant volume, pH, hardness and temperature is of maximum importance," and that the "possession of a privately-owned and adequate supply on the premises"¹⁴³ were important and justified initial investments for a farm. The water supply for farms in the earlier decades were not very good. One of the earlier iterations of farmer Pay Bok Seng's farm in Choa Chu Kang in 1988 had such a low water flow that it would require hours to fill a bucket. This made the washing of his washing of pond filters and other equipment difficult to accomplish in a cost-efficient manner. The site selection,

¹⁴³ R. Jonklass, "Constant flow system for improvement of freshwater fish farming establishments", edited by John Dawes, *International Aquarium Fish and Accessories Conference*, Aquarama Proceedings: First International Aquarium Fish and Accessories Conference (Singapore: Academic Associates, 1991).

therefore was of paramount importance, based almost entirely on the kind of water source.

Besides choosing sources of water with properties that were already considered suitable for farming, water parameters such as organic matter accumulation and oxygen content had to be managed. Pay's farm is an excellent example of these management requirements, as he has had several farms since 1975, and the most current farm was established in 1995. He had stated the importance of these water sources and how they limited where he could site his farm and how he had to adapt his practices such as dealing with low water flow. Many of the ornamental fish farms since the 1960s have been about managing water parameters, which Pay had summarized succinctly as "fengshui (風水)". That is, water and air. He said if he kept water "in good zones" and made sure to "get oxygen in and carbon dioxide out", that was all one really needed in managing a fish farm, no matter the species. Later farmers such as Farmer Tjo Kwe In of Zion Koi Farm had also said that the filters on his farm were designed by himself and were critically important, even if he had a smaller farm than Pay.¹⁴⁴ Due to the high stocking densities of fish in farms compared to natural ponds or rivers, water parameters such as organic matter accumulation and waste production is a factor that they have to deal with (See Figure 1.1 for a listing of some water parameters). The expertise farmers have in

¹⁴⁴ Tjo Kwe In and Max Ng had established their farms in 2000, much later than Pay did, but much of the water management issues they had are in line with Pay's.

running a farm are mostly self-taught through experience. For example with Pay, he had had experience managing his father's farm before he got into koi rearing,¹⁴⁵ and transferred the skills he had learnt at rearing ornamental fish to koi specific techniques. The farmers' expertise in their knowledge of water management and their willingness to share their knowledge earned hobbyists' respect. While they are technically laymen, hobbyists are thus willing to trust their opinions and advice based on their experience.

One of the issues with closed water systems in aquaculture was the need for introducing new generations of fish into a farm, but in a manner that would prevent disease transmission. In 1995, Krishan Rana from the Institute of Aquaculture, University of Stirling, Scotland wrote about induced spawning in ornamental fish, writing that "for any sustained fish production practice, a consistent supply of high quality seed from as many marketable species as possible is essential"¹⁴⁶.

Singaporean farmers, whose livelihoods depended on the fish production of their ornamental species, thus had to figure out ways to obtain this consistent supply. One of the possible methods to achieve this goal was to have breeding stock that would produce young and thus the farmers would not be held up with having to acquire the "seed"

¹⁴⁵ This information was based on a personal interview with Pay on the November 27, 2015, and a self-published booklet that Pay wrote to chronicle the history of his farm. This pamphlet, titled *The 18 Fish Scripts* was written in 2013 with the aid of his wife to be submitted to a visiting Minister of National Development to appeal for a renewal of his farm's land-lease.

¹⁴⁶ Krishan Rana, "Induced Spawning and Other Aids for Ornamental Fish Production," in *Aquarama Conference Proceedings*, vol. 1, 1995, 169-83.

from other producers. If the fish could produce young naturally but under easily controlled and manipulated circumstances, this would be ideal for the farmer. One method was the induced spawning of goldfish and koi by changing the temperature of their water, increasing the temperature to 20°C.¹⁴⁷ However in a country like Singapore, this sort of advice might be difficult to implement, considering that the average temperatures of Singapore are consistently in the high 20s or low 30s. However, generally, affecting the temperature or water quality of the fish's aquatic environment were investigated and found to be triggers for spawning. Some of these manipulations were difficult to simulate in the farming environment, or too expensive; temperature is thus one of the easiest.

Other water condition manipulation also were considered part of the everyday dealing of fish. With hobbyists, adjusting the salinity of a particular volume of water such as in treatment tanks, can help decrease parasitic occurrence, for example, and aid in a fish's healing. The administering of medication is also in the manipulation of water by adding soluble antibiotics to water for koi that had been just imported or just recently moved to a new environment is general practice and accepted as aiding the koi acclimate and prevent further disease from the stress of being moved. Such treatment includes packing the fish in

¹⁴⁷ "Koi Reproduction, Sexing Koi, Spawning Koi, Incubating Koi Eggs, Fry, First Feeding, Growth." accessed 30 December 2017, http://www.pondkoi.com/koi_reproduction.htm.

acriflavine, formalin and a salt solution to decrease mortality of fish when they are shipped.¹⁴⁸ Diseases are generally first treated by increasing the salinity of water towards the brackish range, if the fish was freshwater, or towards the more fresh-water range if the fish is normally in a marine environment. Parasites and other microbial infectious agents were assumed to be more susceptible to the water environment than the host fish, and thus would be eliminated quicker. Dissolved nitrates and other nitrogenous solutes in the water were also removed when the sick and treated fish is removed to a smaller tank and its water swapped out for a cleaner version. Much of this doing so in the farming situation was the application of scientific understanding of disease in the water to the fish's health when it got to its destination, because "fish exported from Singapore normally have very low mortality," and therefore the practical applications were mainly to "ensure a good post-shipment survival."¹⁴⁹ The procedure then was tied up with Singapore's reputation, and meant to enhance it.

In a workshop in 1997's Aquarama conference, Jane Lloyd, a lecturer in Fishery studies at Sparsholt College Hampshire (UK), pointed out the importance of water, and the relationship between water parameters, stress and disease status of fish, highlighting

¹⁴⁸ K. H. Ling and Lian Chuan Lim, "Quality Enhancement of Ornamental Fish prior to Export," in *Aquarama Conference Proceedings*, vol. 1, 1997, 150.

¹⁴⁹ K. H. Ling, L. C. Lim, and Leslie Cheong, 'Quality Enhancement of Guppy for Export: Eradication of Parasites', *Singapore Journal of Primary Industries* 24, no. 1 (1996): 45.

specifically that water quality affects fish directly as an effect of the parameter, indirectly, or indirectly causing stress.¹⁵⁰ The role of water was something that she pointed out to her audience as possessing parameters that would be affected differently in various aspects of the ornamental fish industry. The effort on the part of these workers within the industry are all linked by the same water, and the way that their priorities shift all in the effort of keeping the fish alive, and able to get to their end-goal of the customer's tank. While Lloyd states with optimism that the future of the industry was tied with all aspects of the industrial leaders being concerned with the fish first and the welfare of animals, much of the concern of people within the industry in Singapore were actually with the reputation of the fish exported specifically from Singapore. With a better reputation of good quality fish than Singapore's competitors, this prompted international buyers to buy Singapore's exported fish and cementing Singapore's reputation as having good quality, disease-free ornamental fish. The health and welfare of fish were tied into Singapore's identity.

2.3.1 What does water mean to contemporary koi hobbyists and farmers?

Some of Singapore's reputation became tied into the ornamental fish industry, partly due to the adherence of Singaporean farmers to contemporary understanding of good water management practices. The

¹⁵⁰ Jane Lloyd, "The Fundamental Role of Water Quality for Fish Health and Welfare," in *Aquarama Conference Proceedings*, vol. 1 (Aquarama '97: The 5th International Aquarium Fish and Accessories Exhibition and Conference, Singapore: Academic Associates, 1997), 180.

lack of freshwater in Singapore's mainland, and therefore the issues Singapore has with various kinds of agriculture and their relationship with water favoured aquaculture over terrestrial agriculture, and eventually tied part of Singapore's identity to ornamental fish aquaculture.

As a subset of the ornamental fish industry, the koi aquaculture industry also reflected Singapore's reputation for good quality koi. In Singapore, the koi industry is driven in large part by hobbyists because they are the ones who are buying koi. Their practices are also influenced by those of the farmers, who are respected members of the ornamental fish community.

Many of the koi hobbyists are not scientists in the traditional definition and instead come into the hobby because they were enticed by physical appearance of the koi fish and other social reasons. For example, Dr Tan Hwa Luck, credited as the first veterinary of Singapore to keep koi, said "koi[sic] are the ornamental fish that people like to keep because of the longevity, the beauty, and also the tranquillity that the fish emits."¹⁵¹ Koi were and still are one of the more expensive ornamental fish in Singapore, and therefore keeping them alive and beautiful was an important factor to hobbyists since they represent significant monetary investment.

¹⁵¹ Tan Hwa Luck, interview by Delfinn Tan, March 12, 2015.

One method that hobbyists utilize is by attempting to reconstruct Japanese environmental factors. There are many features of the environment they consider, for example temperature, soil quality of ponds and pond size, but of all of these, water quality is the factor that many hobbyists place as paramount. Hobbyist Jerome Ng said that "the quality of water in Japan" due to its mineral make up and "cooler temperatures like between 5-10°C" were optimum for koi-keeping,¹⁵² that the cooler temperatures and the different mineral qualities of the water in Japan all contributed to making the koi in Japan the most beautiful in the world. However, as Singapore is not Japan, hobbyists feel that they have to build a facsimile to approximate the Japanese aquatic environment. For example, water in Singapore is considered to be acidic in comparison to Japan, and thus hobbyists like Jerome set up various methods to increase the calcium carbonate levels in their water by running water through eggshells or shells from shellfish before using the water in their ponds, hence his homemade filtration set-up as seen in Figure 2.1. His filtration system is meant to introduce more calcium carbonate to the water and reduces the acidity of the pond water. This is an attempt to neutralise the acidity of water in Singapore, and make it comparable to that of Japan.

Another specific parameter that hobbyists had latched onto was water temperature. As Singapore is a tropical country and Japan, in

¹⁵² Jerome Ng, interview by Delfinn Tan, May 6, 2015.

particular Niigata where koi are bred, experiences heavy snowfall during winter, hobbyists believe that cold water is essential to maintaining the desired appearances of the koi. Hobbyists have noticed koi lost their looks within two weeks of arrival from Japan¹⁵³, which they attribute to Singapore's warmer water. In talking about the fading looks, hobbyists specifically refer that the bright reds, deep blacks and luminous white colours of the koi. The white that serious hobbyists like Jerome preferred is a specific colouration of the koi that they attribute to the cold water, as the white of the koi has been said by hobbyists to be more luminous and translucent during and just after Japan's winter, or during early spring, instead of during summer.

The importance of the water temperature in affecting the appearance of koi is believed by hobbyists and reinforced by the books and manuals that non-Japanese hobbyists use, such as *Garden Pools*, where the authors of such manuals and books would mention without fail the climate of Japan, making statements like koi "do best in temperate climates where the water in a pool three feet deep won't freeze solid in the winter."¹⁵⁴ Japanese authors Shuiji Fujita and Shoichi Iizuka of a translated koi manual *Nishikigoi Mondo* wrote "perhaps because the quality of the soil and water [of Niigata] was suitable for Irogoi [an alternative name for koi]" thus "numerous Nishikigoi varieties

¹⁵³ Jerome Ng, in discussion with the author (Delfinn Tan) at Nippon Koi Farm, May 22, 2016.

¹⁵⁴ *Garden Pools*, 47.

appeared."¹⁵⁵ The English translation of *Kokugyo* described the Niigata region as having "white mountains covered with snow [which] will turn into lush green mountains in the spring. In those valleys, there are an abundance of mud ponds for Nishikigoi", and that "unlike sterile concrete ponds, mud ponds consist of clay that nurtures the development of the Koi."¹⁵⁶ Claims such as "nishikigoi in Niigata grow up in beautiful woods with three conditions: peaceful surroundings, superb mud ponds and exceptional water"¹⁵⁷ which come from "pure waters from melting snow" forms the background against which Singapore hobbyists, who generally can only easily access English-medium manuals and literature such as these, and creates the impression of the importance of water temperature in the breeding and rearing of koi.

Further actions by farmers in Singapore also contribute to the hobbyists' belief. When farmers import koi from Japan on an annual basis, they were generally purchased and shipped in early spring, just after Japanese winter. The fish were not shipped with ice, but the cargo hold of the plane meant that the water the fish were in were cooler than Singapore's generally high 20s and low 30s Celsius. When the fish were unpacked and released into ponds or tubs on the farm, they were usually placed in water which was chilled. For example, during the

¹⁵⁵ Shuji Fujita, *Nishikigoi Mondo*, ed. Mark Gardner and Kiyoko Tashiro, trans. Aika Watanabe, English Edition (Tokyo, Japan: NABA Corporation, 2009).

¹⁵⁶ M. Kodama, S. Fujita, and A. Kawabata, *Kokugyo* (Shin Nippon Kyoiku Tosho Company, Limited, 2002), 12.

¹⁵⁷ Kodama, Fujita and Kawabata, *Kokugyo*, 28.

unpacking of koi shipment on May 22, 2016, the farmer and owner Pay had, with his workers and volunteers, placed the koi in bags of chilled water and then floated these bags in prepared concrete ponds filled with large slabs of ice. In another farm Diamond Koi, the owner also had placed his shipment of koi in tubs which had water chillers that cooled the water of the newly arrived koi on April 28th 2017. Both the farmers were respected members of the hobbyist community – Pay has been called a "shifu,"¹⁵⁸ or teacher, and several hobbyists have learned fish husbandry techniques from him. In fact, all koi farmers in Singapore but Pay were hobbyists themselves, and they all were respected for their experience and knowledge in handling koi. Hence, their practice in chilling the water of newly arrived from Japan koi (see Figure 2.4) was interpreted by the hobbyists as a reinforcement for the idea that cooler water maintains the better appearances of koi, resulting in many hobbyists having water chillers running for their own fish tanks. An anonymous hobbyist, while he was observing the unpacking of the koi shipment in the Nippon Koi farm, said that while the bill for chilling his water for his koi ran his household bill very high, by "more than five hundred a month,"¹⁵⁹ he felt it was worth the expenditure to maintain his fish's appearances.

¹⁵⁸ Jerome Ng, personal communication with the author, December 7, 2016.

¹⁵⁹ Anonymous hobbyist, personal communication with the author at Nippon Koi Farm, May 22, 2016.

The farmers are highly respected. While they are all considered laymen because they do not have specific scientific degrees in aquaculture, many hobbyists consider farmers to be highly knowledgeable. When in need of advice regarding diseases or parasitic infections of their fish, hobbyists like Jerome turn to the farmers for their "past understanding and combinations of medications"¹⁶⁰ because they trust these laymen who are considered part of their community. Hobbyists are less likely to rely on off-the shelf medications and chemicals, calling it a "layman's combination", where a hobbyist has to "seek the right and reliable layman" to get said combination.¹⁶¹ The farmers' knowledge is therefore given weight due to respect and experience, and hobbyists are more liable to trust their word and attempt to imitate their practices.

The understanding koi farmers have of water parameters are paramount. There are factors that farmers have to deal with that hobbyists do not. Many hobbyists are unable to maintain more than one pond (see Figure 2.2) due to the scarcity of land, while a farmer usually leases enough land to have several ponds. On Pay Bok Seng's 2.7 hectare farm, for example, he has enough land to build more than thirty ponds, and some of them are rented to hobbyists as a 'koi hotel' where hobbyists can rent ponds on Pay's farm and have his expertise in grooming and rearing the fish, as well as his immediate attention if the

¹⁶⁰ Jerome Ng, interview by the author, December 7, 2016.

¹⁶¹ Jerome Ng, interview by the author, December 7, 2016.

fish fall ill. Besides space, koi farmers also work with a larger scale. They work with more ponds and a higher density of fish, so the management of waste-products, water quality and disease is of a higher priority and at a larger scale. Their ability to manipulate these conditions, water parameters in particular, is paramount and depends on their understanding of these water parameters themselves, and how these parameters affect the lives and appearance of the fish they are rearing and grooming for sale.

Ornamental fish farmer Desmond Yeoh had mentioned in an oral history interview that part of his village's ability to rear good quality guppies had been due to the somewhat brackish water source near his village.¹⁶² According to him, while guppies were a freshwater fish, the presence of seawater in Sungei Khatib where his village had been, had been good for the development and culturing of guppies. The concern with water quality applied to all kinds of fish farms, including koi farms. Pay had also complained¹⁶³ about his constant moving of his farm due to expropriation of his farm numerous times. He was unable to consolidate enough funds to move his farm overseas and start over there, but most importantly, he complained that the water sources were critical for his farm and in determining what kinds of fish he could rear. "We are not a coffee shop," he had said, because to him, farms were not franchise businesses. A fish farm could not be transplanted readily and

¹⁶² Desmond Yeoh Chew Sing, interview by Jesley Chua, July 18, 1999, 002180/07-08 reel 7

¹⁶³ Pay Bok Seng, interview by author, November 27, 2015.

effortlessly without considering the water sources for the fish. The setting up of his farm in terms of piping water in and organizing the kind of fish he could rear with his ability and knowledge was far more complex.

Water is also the source of Singapore koi farmers' respect amongst the hobbyists. Pay had in the early 1990s gone out to customers' properties to help maintain their ponds. Once, he had spent all night in a customer's pond cleaning and maintaining their equipment, which had impressed the customer and according to Pay, earned him his permanent respect. Max Ng of Max Koi farm was known for maintaining a large reservoir of water usable for koi ponds and letting any hobbyist take as much as they needed during particularly dry years¹⁶⁴ which hobbyists find admirable. This sets up farmers for possessing roles of respect and knowledge amongst hobbyists.

The consolidation of all these factors and the history of water parameter knowledge resulted in the contemporary koi hobbyist water set-up. While older manuals were not very detailed in why one must change the water at their recommended frequency, newer manuals in subsequent decades from the late 80s and 90s onwards mentioned water characteristics that are measurable by tests that the homeowner and hobbyist could administer, allowing them to use proxy tests to understand the invisible characteristics of the water. These

¹⁶⁴ Jerome Ng, conversation with author on December 12, 2015.

characteristics included pH levels, temperature, and other chemicals in the water. In a lot of manuals, these chemicals were stated to be nitrogenous waste products expelled from the fish. While the solid waste created by the fish is very obvious as they settle at the bottom of tanks or ponds, the common consensus amongst scientists now are that it is the invisible water characteristics that the living fish alters that affects a fish's state.

In addition, while Singapore's water is clean and potable straight from the tap, one of the various additives in the tap water includes chlorine. Singapore's water complies with the WHO guideline range of chlorinated water from 0.2 mg/L to 5mg/L, by adding chlorine and its disassociated by-products which are meant to disinfect the water and make Singapore's drinking water safe from waterborne diseases like cholera. They are however harsh on the delicate respiratory tissues of fish that have to live in and respire the water. Chlorine can also be harsh on other parts of the fish's body, such as the eyes and skin. Hobbyists therefore do not use the tap water directly in their ponds. Instead they have to treat the water. A standard part of the water treatment process includes exposing the water to air for 24 hours to allow the chlorine to evaporate, or by adding de-chlorinators.

Another possibility is for hobbyists to use untreated ground water for their ponds and tanks, and perform their own disinfection treatments. For example, Jerome has a UV lamp that helps disinfect the

water without additives, and then mechanical filters to prevent debris and other large particulate matter from getting into his pond. The water is also meant to be recycled. So for Jerome, water source and pond water that his fish live in pass through the same filter. The filters thus treat new water and also pond water in order to remove fish waste, by attempting to prevent unwanted microbes from entering the pond system, as well as using the filter to house useful denitrifying bacteria. Some other hobbyists also include shells (such as from shellfish or eggshells) that are composed of calcium carbonate in order to increase the calcium levels of the water and thus increase the pH levels of the water.

Like most other fish keepers, Singaporean koi hobbyists try to modulate the water quality at all times to maintain their koi. That includes trying to aerate the water as well, because fish obtain dissolved oxygen from the water, and excrete through their gills. Hobbyists are constantly working in an attempt to keep the flow of water in acceptable, 'good' range of qualities for their koi. Much of this activity is learnt from observing farmers, and getting recommendations on both pond construction and filter types from farmers and other hobbyists. Jerome has a pump that moves his pond water through the filtration system. Jerome claims that the Japanese brand *Tsurumi* is better than European brands since the European brands burn out far quicker than the Japanese brand pumps (Figure 2.3). Considering the large volume of

water has to be constantly moving, it is not a surprise that koi hobbyists like Jerome demand that the equipment has to be able to cope with it, especially since the financial and emotional value that hobbyists invest in their koi is fairly substantial.

In their admiration, Singaporean hobbyists therefore follow many of the farmers' practices, whether by attempting to cool the water in their own homes, using the same water that farmers use, seeking the farmers' advice in terms of feeding their fish or when they become ill. Their fish could become ill by parasitic infection, exhibit lesions, listless behaviour, loss of colour, or infections by micro-organisms, all of which hobbyists learn from books and more experienced hobbyists and farmers to be due to water parameters.

The farmers thus are the focal point of the ornamental fish industry in Singapore, where they are repositories of knowledge, water-management practices, and the translators of the knowledge. Their practices influence how Singaporean koi hobbyists modulate and manage the water environment about their own koi.

2.4 Conclusion: Recreating Water

In this chapter, I have gone through the use of water as a life-sustaining medium which possesses properties that people manipulated in order to keep their fish alive, especially in aquaculture. The development of water parameters were motivated by the need to understand fish's relationship with water. As a result, understanding

about water was translated into water parameters, a way for humans to understand and ultimately manipulate water and thus the relationship of fish and water. Humans also motivated to exert of control over fish quality, which was done via manipulating water parameters. This led to the linking of fish health to good water quality, and generally in the Singaporean ornamental fish aquaculture industry water came to be treated as a proxy for disease. The closed-water systems in enclosed aquaculture spaces such as farms and ponds increased the level of control that humans could exert on the koi's environment and opened a space for government intervention, especially in the context of disease. The association of disease and pollution that aquaculture brings to water made it ripe for the implementation of disease management in order to control these issues. This implementation played out in the history of Singapore's ornamental fish aquaculture industry, specifically in the koi industry.

With the translation of the relationship of koi with water into a set of parameters that farmers could manipulate, the industry was ready for the translocation of koi from Japan to Singapore. Part of the manipulations of water parameters in Singapore koi aquaculture were made to adapt Japanese cultivation practices into the Singaporean environment, ultimately in an attempt to recreate the Japanese aquatic environment to maintain and sustain koi and allowed the translocation of koi into Singapore. A historical overview of the ornamental fish

industry in Singapore is necessary in order to contextualise the health management issues that arose due to attempts at increasing control of koi health by translocating and translating Japanese aquaculture practices into Singapore, which I shall cover in the next chapter.

Chapter 3: History of Ornamental Fish in Singapore (1970s to present)

The cavernous hall was huge, like a ballroom, with two large double-doors opening to usher a visitor in face first to a giant marine tank the size of a bedroom wall filled with colourful coral, waving sea-anemones and marine reef-fish (Figures 3.1 & 3.2). The rest of the exhibitions within this hall were slightly less intimidating, but no less interesting, displaying a bewildering variety of ornamental fish products, such as tanks, tank-decoration, and fish food. Long rows of tanks to the side immediately draws attention, despite the brightly coloured cacophony of aquarium products directly ahead. At first glance they seemed blue-lit, but when examined up close they were actually lined with bright blue material and lit overhead with white fluorescent bulbs so that the tanks appeared to glow blue (Figure 3.3). The blue background of the otherwise bare tanks made the white of the various fish stand out, snowy-white in brilliant contrast as they swam about the small displays. The viewing area was quiet, as these were fish entered for competition, and only viewers interested in observing these fish were walking slowly around in silent contemplation, unlike the hovering of vendors at their individual exhibition stalls. Ornamental fish were everywhere – so many of these were owned by Singaporean hobbyists, and it was almost bewildering why any one fish won first prize over its compatriots. Who were the judges? How did the owners of

the fish figure out what was winning criteria, and how did they achieve them?

On 28th May, 2015, Aquarama 2015, the 14th International Ornamental Fish and Accessories Exhibition was open to public visitors at the Suntec Singapore Convention and Exhibition Centre in Singapore's CBD, occupying and combining two halls to host the competitions and accessories exhibition. The live fish competition entries had been judged the day before, and the winning entries had the winner ribbons affixed to the tanks (Figure 3.4). The crowd consisted of retirees and those with more flexible work-hours, allowing the few visitors time to stroll leisurely amongst the fish, watching the Siamese fighting fish (*Betta splendens*) and guppies stare back at them.

Half the floor space of the hall was taken up by the competition tanks; the other half consisted of exhibitions and a presentation-area. Visitors who weren't interested in the fish could attend and listen to talks held in the back of the hall; all of them related to all sorts of aspects of the ornamental fish industry. Topics covered included reef protection, CITES regulations, fish health, and fish disease, as well as the future of aquaculture in aquaponics. All of these were important topics, spreading vital information to hobbyists and anyone within the ornamental fish industry in forms easy to incorporate into aquaculture practice. Singaporean groups made a decent showing, as both the Singaporean Guppy Association, Singapore Goldfish Appreciation Club

have stalls. As this exposition was held in Singapore's Suntec City, the Agri-food and Veterinary Authority of Singapore (AVA) also had their own stalls. The majority of stalls are otherwise mostly from China, exhibiting their accessories. There was one stall that was selling koi feed (Figure 3.5), but otherwise no other exhibits of koi related paraphilia.

At first I thought that the low attendance was due the day and time of the week; after speaking to an official from the AVA booth, I was told that in previous exhibitions, even the weekday sessions would have several times more visitors, and weekends would be packed till there was no space between the stalls. In fact, there would have been more stalls than in 2015. It was, I found out, also the last year the Aquarama would be held in Singapore, as the Aquarama in Singapore was making losses. From 2016 onwards, the Aquarama would be held in China where the voracious attendance would result in a profit. In other words, the Aquarama 2015 was an image of the decline of Singapore's ornamental fish industry. There was not enough local market to sustain the Aquarama or the ornamental fish industry.

This poor showing of the ornamental fish industry and koi industry in 2015's Aquarama directly contrasted with the hopeful beginnings of the koi industry when koi was first found for sale in the 1970s in Orchard Road, Singapore's commercial centre, and the subsequent enthusiasm for koi in the first Aquarama in 1989, when Shigezo Kamihata, the president of Kamihata Fish Industries from

Hyogo, Japan spoke on how to appreciate nishikigoi. According to the United Nations Commodities Trade database, Singapore's 2016 ornamental fish export value was the same as in 1999, having dropped from the maximum in 2008.¹⁶⁵ What led to this difference?

In the previous chapter, I had outlined how water management in aquaculture grew from the need to understand more about the water parameters necessary to sustain aquatic life, and how this led to biosecurity issues of water in ornamental aquaculture that eventually played out in koi aquaculture. The translation of water's relationship with fish into water parameters allowed koi farmers to recreate the Japanese aquatic environment for koi. Before elaborating on the biosecurity issues and regulations in the koi aquaculture industry that resulted, the history of ornamental aquaculture needs to be clearly delineated to give a historical context to the impact that this tension had on the ornamental fish industry, and koi aquaculture in particular. In this chapter, I shall show how outlining the history of ornamental fish aquaculture in Singapore is complicated by people in Singapore learning and translating aquaculture practices of Japan's koi aquaculture into Singapore's aquaculture practices. I shall do this by examining the factors that allowed the rise and growth of the industry that culminated with the appearance of Koi Herpes Virus (KHV) in 2006. The KHV

¹⁶⁵ United Nations Statistics Division - Commodity Trade Statistics Database (COMTRADE), accessed 30 December 2017, <https://comtrade.un.org/db/dqBasicQuery.aspx>. See Figure 3.6 for a graphical representation of the ornamental fish export value.

appearance that marked the clash of biosecurity and state issues, and then the fall out of this event. The historical analysis would be presented in a before-after manner so as to best highlight the pivotal event that took place, especially since the time-scale of this history is only in the matter of decades. This allows a clearer examination of the factors involving the translocating and learning koi aquaculture practices from Japan and how they were translated and adapted into local aquaculture practices in order to recreate Japan's environment for fish.

The timeframe of this chapter takes place from the late 1960s till the present. The rise of the ornamental fish industry takes place from then till the late 1980s, when the establishment of two major institutions took place in the end of this time period: the set-up of the *Singapore Journal of Primary Industries* and the Aquarama. From the 1990s to the 2000s, the main events were the growth and settlement of the koi industry, and the consolidation of the Primary Production Department (PPD) into the Agri-food and Veterinary Authority (AVA) on 1 April 2000.¹⁶⁶ The people involved in this time period were from a large range of social classes. Some of the farmers were from families of traditional farming, while others became farmers after first being hobbyists of ornamental fish. Hobbyists generally had the income to support an expensive hobby and were initially highly educated professionals like doctors. Hobbyists, however, were not a single group. Some of them

¹⁶⁶ "2000 and beyond - The birth of AVA", Agri-Food and Veterinary Authority of Singapore <https://www.ava.gov.sg/about-ava/who-we-are>

were interested in keeping koi as a display of status and wealth, others were intensely interested in the actual act of koi husbandry and less interested in winning prizes at koi shows. Government officials on the other hand acted as translators of scientific information from scientists, or were scientists themselves generating scientific knowledge within the government sector for the aquaculture industry. Due to these roles being so diverse, it is difficult to make sweeping statements about each social role, and the history in this chapter (and the next) will elucidate the complexities of their roles and relationships with each other as they transmit, generate and translate knowledge of koi aquaculture in Singapore.

3.1 The Rise of the industry: 1970s to 1980s

By the 1960s, many villages in Singapore had made forays into ornamental fish farming had been started by many villages, so it was not unfamiliar ground to the Singapore agricultural landscape. Since the mid-nineteenth century, fish and aquatic life that had been mainly of scientific interest to Victorian naturalists and scientists eventually led to the development of the modern aquarium and fish-keeping hobby.¹⁶⁷ Tropical fish had a reputation of being "new exotic fish" and whose bright colouration "made aquarists' hearts beat faster."¹⁶⁸ Consequently, tropical fish were "prestigious" amongst European hobbyists and resulted in a high demand in Europe and other higher latitude countries

¹⁶⁷ Brunner, "Exotic Species and Transport," 78.

¹⁶⁸ Brunner, "Exotic Species and Transport," 79.

as they were which were the main destinations of export for ornamental fish. Eventually Singapore's ornamental fish industry developed to meet this demand. In 1968, the Primary Production Department (PPD) of Singapore first started farm licensing "to provide essential data on the structure of agriculture in Singapore" in order to "formulate policies and plans to further develop intensive farming to ensure optimal use of limited land resources."¹⁶⁹

The early 1970s was a period of growth in Singapore's history, of both population and economic development. Singapore's population, increasing economic development with Singapore's Independence from both the British Empire and later from Malaya in 1965 marked a change in the Singaporean industries. Land was necessarily acquired by the newly formed Singaporean government to establish housing, and reducing farms that contaminated water. The large population Singapore's government needed to house also needed water, and pig farms had the reputation of being sources of water pollution.¹⁷⁰ It is against this background that the ornamental aquaculture industry developed in Singapore, where water was a limited resource and always harboured a potential for spreading disease.

In comparison to other forms of agriculture, ornamental fish farms utilized less space, were mostly self-contained, and their water

¹⁶⁹ <https://www.ava.gov.sg/about-ava/who-we-are> accessed 12 Oct 2017

¹⁷⁰ Koninck, Drolet, and Girard, "Rationing Agriculture", in *Singapore: An Atlas of Perpetual Territorial Transformation*, Singapore: NUS Press, 2008, 40.

consumption and water-wastage was judged by the PPD to be a lot less polluting than pig-farming. In addition to these attractive properties of freshwater fish aquaculture, ornamental fish were vastly more profitable. Instead of being sold per weight, ornamental fish such as guppies were sold individually. Singapore quickly garnered a reputation not only for colourful, good quality fish, but also for consistent quality and fish that lived longer after arrival. The ornamental fish industry seemed poised for huge success.

3.1.2 History of ornamental fish farming: From fish farms to Aquarama

In the 1960s, several villages in the northern parts of Singapore bred fish for ornamental purposes.¹⁷¹ While many villagers were still performing subsistence farming, several farmers started breeding guppies. In Bah Soon Pah village, for example, a significant number of farmers took up ornamental fish breeding,¹⁷² and in Chye Kay village the villagers started breeding guppies and developed various breeds of guppies that eventually gained Singapore the reputation for good quality guppies that were in strong demand from the 1970s to the 1980s.¹⁷³

However there was a limit to the price of a guppy, even that of a highly desirable new breed. Farmers like Desmond Yeoh's family were eventually convinced to move away from breeding guppies, which

¹⁷¹ Naidu Ratnala Thulaja, "Chinese villages in the North," *National Library Board Singapore*, 2005, http://eresources.nlb.gov.sg/infopedia/articles/SIP_385_2011-01-07.html

¹⁷² *Ibid.*

¹⁷³ Desmond Yeoh Chew Sing, interview by Jesley Chua, July 18, 1999, 002180/07-08 reel 7.

produced tiny fry and tiny juveniles that were difficult to sort in favour of larger fish such as goldfish. Tiny guppy fry were extremely small and would require sorting and counting by hand in the thousands, and yet in the 1970s were only sold for around ten dollars for a milk tin's worth which was about a thousand fry (approximately one cent each fry). The adult guppy itself sold for perhaps thirty cents, if a normal male or for a dollar for a new or unique male breed, and did not vary in price no matter its size. The sorting took up a lot of time for what must have felt like little profit. Goldfish, on the other hand, produced fry that were worth a three times more than guppy fry, and could be sold based on different sizes as goldfish grew significantly larger than guppies.¹⁷⁴ The farmers that continued to stay in the ornamental fish business like Desmond's family thus would make the switch to larger and more profitable ornamental fish.

As space became more limited, and farmland was slowly re-appropriated by the government for other development projects, it became less economical for farmers to try breeding fish on their own, as that required large space, reliable water sources and a large investment of time in sorting fish. In Chye Kay village, farming families faced space and time constraints where each family could only reasonably maintain and breed one or two different breeds of guppy since breeding meant a having to keep the same breed in various sizes and ages for sale.¹⁷⁵

¹⁷⁴ Ibid.

¹⁷⁵ Desmond Yeoh Chew Sing, interview by Jesley Chua, July 18, 1999, 002180/07-08 reel 8.

Some farmers started to become dealers by using their contacts with various farming families. They were able to turn other breeding farmers into sources for various fish breeds and species, and offer both good and consistent quality as well as a large variety to the international market.

Singapore's domestic market was too small to sustain an industry in small ornamental fish like guppies. Part of this was the limited land to maintain large varieties of small fish, and larger ornamental fish started to catch the interest of Singapore's domestic market. The Japanese government gifted PM Lee Kuan Yew a pair of koi in 1969,¹⁷⁶ and these fish and goldfish were starting to catch the attention of domestic hobbyists. In contrast, guppies were known as "longkang fish" or monsoon drain fish,¹⁷⁷ and were considered common. They often couldn't fetch more than one Singapore dollar in the 1970s. Goldfish were not only larger, fetched three to five times the price of a guppy depending on its size and breed, there were rarer breeds that were at the time not exported out of Japan.¹⁷⁸ Desmond Yeoh was one of the first farmers to be able to import the ranchu goldfish, at the time rare and highly desirable breed, from Japan and export it to other countries. The ornamental fish industry in Singapore was starting to become large enough that the PPD officials were starting to become involved in more than a regulatory fashion. Many of the officers were starting to work

¹⁷⁶ Potiek Chia, "All about the Birds and Fish and Gracious Living in S'pore," *The Straits Times*, 27 February 1970.

¹⁷⁷ Ibid.

¹⁷⁸ Ibid.

with ornamental fish farmers, and their work in trying to aid farmers with scientific precision and understanding resulted in the establishment of *The Singapore Journal of Primary Industries*, which will be elaborated in more detail in section 3.1.4.

This pattern of breeding small ornamental fish then shifting to larger profitable ornamental fish was mirrored in the koi industry. Koi farmer Pay Bok Seng started from a similar trajectory of breeding tropical ornamental fish, and then branching into more profitable and rarer large freshwater fish, the koi. Only in the 1980s were koi more commonly available for the domestic Singaporean market. Despite koi having been present in the minds of hobbyists since 1969,¹⁷⁹ the koi themselves were bred and maintained by staff from the Van Cleef Aquarium of the PPD, and were mainly for display and not available for purchase from the common people before the 1980s.

There is some conflicting evidence as to who first imported koi for public consumption into Singapore. Yeoh claimed to have been the first to import koi in the 1980s,¹⁸⁰ while another dealer in Orchard Road of Singapore had been credited with the first importing of koi for the domestic market.¹⁸¹ The murkiness of the koi's first entrance to Singapore's domestic market aside, koi were much larger than goldfish, and the prices that they could claim were much higher than even

¹⁷⁹ Potiek Chia, "All about the Birds and Fish and Gracious Living in S'pore," *The Straits Times*, 27 February 1970.

¹⁸⁰ Interview with Desmond Yeoh, Interviewed by J, 1999, reel 9.

¹⁸¹ Pay Bok Seng, interview with author, 2015.

goldfish breeds. In 1989, doctors and white-collar professionals like Dr. Tan Cheng Bok established the Singapore Koi Club, marking the presence of a domestic demand for koi. At that time, most of Singaporean hobbyists were doctors, associating koi-keeping with the cultured elite land-owners.¹⁸² Farmer Pay Bok Seng, having had some contact with Singapore's short-lived Industrial Farm (IF) and their attempt to breed koi to a commercial level, decided to start breeding koi. Although Pay was not a koi hobbyist nor a white-collar professional like the Singapore Koi club founders, Pay was self-taught, and viewed koi squarely in the economic sense, breeding koi solely as a livelihood as ornamental fish, much like how he had bred other tropical fish on his farm as commodities to earn revenue and profit.

In 1989, PPD official Dr Ling Kai Huat pushed to hold the first Aquarama, an exposition and forum for exhibiting ornamental fish and equipment. He believed the ornamental fish industry was a robust and significant industry that warranted publicity. The first Aquarama was a success, and the ornamental fish trade continued to grow to become a principle part of the Freshwater Aquaculture section of the PPD. In the global trade of ornamental fish, Singapore's reputation as a marker of high-quality fish soon developed. Singapore's reputation for high-

¹⁸² Tan, Hwa Luck, interview with author, December 3, 2015. Dr Tan mentioned that all the other hobbyists he knew of in the 1960s and 1970s were medical doctors. The Singapore Koi Club was founded in 1989 and their website named the founding members as all doctors except for Mr. Lim Kim San, a former Cabinet Minister.

quality ornamental tropical fish was marked through the increasing export values of ornamental fish and aquarium plants, increasing from S\$35.2 million in 1978 to \$68.2 million in 1988,¹⁸³ which led to the PPD announcing its commitment to "promoting Singapore as a major producer of and exporter of ornamental fish in the world."¹⁸⁴ That year, Singapore was considered to have produced about 60% of the exported ornamental fish in local farms like Desmond Yeoh's, and the PPD was proposing to increase farmland allocated to ornamental fish farming for the next six years till 1995.¹⁸⁵ Despite the constraints with water and land availability, research in aquaculture related subjects was increasing (see Chapter 2), and the PPD was generally positive that aquaculture was a growing and viable industry for the next decade at least.

3.1.3 Interaction of Singapore and Japan as industry partners

It is at this point during the historical recounting of the ornamental fish industry of Singapore that Japan's interaction with Singapore's industry has to be outlined and analysed. As already mentioned in the previous section, Singaporean farmers had already noticed certain fish such as Japanese-only breeds of goldfish and Japanese koi were of great interest to customers in the 1980s. This implied that Singapore and Japan had a positive trading relationship. The trading relationship stemmed from Singapore's attempt to emulate

¹⁸³ Fernando & Lim, "Status of Ornamental fish Trade and Industry in Singapore," 7.

¹⁸⁴ Ibid.

¹⁸⁵ Ibid.

Japan's transition from WWII to its post-War status "Number One".

Japan was a model for Singapore to learn from. It was not just Japan's economic model that Singapore could emulate. The knowledge and technological applications that Japan had embodied in their fish like the Japanese only goldfish and Japanese koi were examples of technology and practices that were desirable for emulation and adaptation.

The typical contemporary Singaporean would pinpoint the start of Singapore's interaction with Japan at the beginning of 1943 and the end of it with Japan's surrender in World War II. However, interaction between Singapore and Japan extend past the end of World War II. While the Japanese occupation of Singapore had spelled a short, brief period of fear and pain in Singapore, the dominant narrative in Singapore had been occupied when the British Empire had withdrawn and given up Singapore to the Japanese occupying forces more readily than expected, and thus provided the momentum to push for independence in the wake of WWII. In the 1980s, a few short decades after the end of WWII, Japan became, instead, a model of governance for authorities in power.¹⁸⁶ Simon Avenell wrote that the Singaporean authorities' push to learn from Japan was "really about teaching people to be productive, patriotic, and compliant *Singaporeans*,"¹⁸⁷ ostensibly because Japan had "supposedly become 'number one' without losing its

¹⁸⁶ Simon Avenell, "2 Beyond Mimesis," *Imagining Japan in Post-War East Asia: Identity Politics, Schooling and Popular Culture* 4 (2014): 29.

¹⁸⁷ Avenell, "Beyond mimesis," 29.

Asian identity," something that Singapore's still new and shaky government was searching for. Japan's apparent ability to fuse its Asian identity with Western practical knowledge was highly valuable and something to be emulated. Japan's lionization by American intellectuals also contributed to the perception of post-war industrialized Japan as the perfect model for fusion of Asian and Western values. Ezra Vogel's *Japan as Number One: Lessons for America* (1979)¹⁸⁸ and David Bayley's *Forces of Order: Police Behaviour in Japan and the United States* (1976)¹⁸⁹ both not only propelled this perception of Japan into the collective, global consciousness, Vogel and Bayley's perception of being experts on Japan also resulted in them being invited to Singapore to participate in Singapore's Learn from Japan campaign as advisors.

While Avenell considers Singapore using Japan as a model but inviting Western intellectuals as experts to evaluate their policy an ironic action, I suggest this action not mimetic isomorphism,¹⁹⁰ but more an attempt to merge both Asian and Western ideas into a coherent whole in Singapore's policy making. The recognition from the West not only legitimizes Japan as an appropriate model to use, but also legitimized Singapore's own nascent national identity. Singapore's "Learn from Japan" campaign was an attempt to shape and regulate

¹⁸⁸ Vogel, Ezra F. *Japan as number one: Lessons for America*. Harvard Univ Pr, 1981.

¹⁸⁹ Bayley, David H. *Forces of order: Police behavior in Japan and the United States*. Univ of California Press, 1976.

¹⁹⁰ Mark S. Mizruchi and Lisa C. Fein, "The Social Construction of Organizational Knowledge: A Study of the Uses of Coercive, Mimetic, and Normative Isomorphism," *Administrative Science Quarterly* 44, no. 4 (1 December 1999): 653–83.

Singapore's social and economic changes.¹⁹¹ The learning from Japan was meant to learn but also adapt what worked for Japan into the local landscape.

Many of the reasons why Japan became the model for Singapore in the 1980s stemmed from the transitional and unstable issues occurring in the 1970s; Singaporean leaders were concerned with labour militancy and 'individualistic' mind-set of workers, as they were convinced that "the success of the second industrial revolution depended on the *acquiescence of labour* to the disruptions that would be caused by the restructuring of the economy,"¹⁹² which Japan had apparently managed to accomplish successfully. Singapore's leaders' anxiety that a mostly English educated population would leave Singaporeans vulnerable to "permissiveness, 'unfettered' individualism, decadent materialism and 'soft options' of the West" conflicted with the need for a common language and deracinated population to reduce the chances of recurring tumultuous race riots that had occurred shortly after the end of World War II. This conflict eventually led to the development of a push for multi-lingualism and bilingualism, in an effort to stem anxieties of Western influence and corruption.¹⁹³

Japan's strong identity and associated systems were an obvious model. Much of Singapore's post-WWII identity was based on

¹⁹¹ Avenell, "Beyond mimesis", 31.

¹⁹² Robin Ramcharan *Forging a Singaporean Statehood, 1965-1995: The Contribution of Japan*. Vol. 9. Martinus Nijhoff Publishers, 2002, p189

¹⁹³ Avenell, "Beyond mimesis", 34.

Singapore's lack of identity, and finally became reliant on the commodities that Singapore exported, a primary one being ornamental fish. Singapore's identity is "built on the lack of it", and not a "proud and self-confident nation."¹⁹⁴ Wee Mon-Cheng, who had been an ambassador posted in Tokyo from June 1973 to September 1980, wrote in the preface of his book *The Chrysanthemum and the Orchid* that a "learn from Japan" movement had been started earlier than 1980,¹⁹⁵ hence his compiling speeches and writings from his time as an ambassador for the 1980s' audience to help understand why learning from Japan was necessary. The editor of the book had added "with each passing day, the volume of Japanese investments in the Southeast Asia increases," and while "there was a time in the fifties and sixties when sad memories of World War II deterred the older generation from purchasing Japanese goods," but that with time the younger generation find Japanese goods to be worthy of purchase, which in turn meant that the increasing Japanese economic influence has "created an appetite for books on Japan and the Japanese."¹⁹⁶ As most of these were published in Japan, the editor Tan Chee Teik judged Wee Mon-Cheng's book "timely" for the consumer's demand.

Japan's economy had direct lessons for Singapore. In one of the

¹⁹⁴ Sim Seok-fang, "Asian values, authoritarianism and capitalism in Singapore." *Javnost-The Public* 8, no. 2 (2001): 45-66.

¹⁹⁵ Wee Mon-Cheng, "Note from the Author", in *The Chrysanthemum and The Orchid: Observations of a Diplomat*. 1st ed. Singapore: Maruzen, 1982, xiii.

¹⁹⁶ Tan Chee Tiek, "Note from the Editor", in *The Chrysanthemum and The Orchid: Observations of a Diplomat*. 1st ed. Singapore: Maruzen, 1982, xiv.

compiled speeches, Wee Mon-Cheng concludes with a quote by a Japanese industrialist Ichiro Hattori, then the Senior Management Director of Seiko Watch Co. Ltd, that "Singapore must let the whole world know about the good quality of her products. In the Pre-war days, 'Made in Japan' is synonymous to lousy goods. Now it has a totally different meaning."¹⁹⁷ This encapsulated the whole reason for the "Learn from Japan" movement in Singapore. In the wake of Singapore's anxiety, Singapore was eager to gain a similar reputation such that commodities that had passed through Singapore's land and bore Singapore's mark would be considered to have an excellent quality. As mentioned earlier in Chapter 2, farming practices in water management had been critical in increasing fish quality compared to other international competitors, and instrumental in starting to tie ornamental fish quality to Singapore's identity. As a result, one of the commodities that Singapore could use to achieve a similar reputation of quality was ornamental fish, and the industry would become linked to Singapore's identity in the need to maintain the quality of the ornamental fish and thus Singapore's identity.

Japan not only was a model and had lessons for Singapore, Japan also actively spread technology and practices. For example in the building of dams and technology, while started in from 1931 to 1945 Japan, was the force through which Japan was developing technology as

¹⁹⁷ Wee, "Japan-Singapore Trade: Challenges to Singapore Exporters", in *The Chrysanthemum and The Orchid*, 94.

a force for motivating creativity, and further influenced Japan's international policies post-WWII.¹⁹⁸ It influenced how readily Japan was to share technological and aquaculture practices with Singapore, and facilitated how Singapore farmers and hobbyists could enter Japan readily to learn more about koi aquaculture.

3.1.4 The start of the Singapore Journal of Primary Industries: 1973 onwards

In the mid-1970s, the ornamental fish aquaculture industry grew to become a significant part of the aquaculture section of the PPD. Disease management and efficient growth of the fish developed into a particular concern of the PPD. Part of the PPD's scope of duty included providing technical advice to farmers, as well as setting health and cleanliness regulations. In order to establish these regulations, officers like George Tay under the supervision of Leslie Cheong of the Freshwater Fisheries section of the PPD were encouraged to conduct their own experiments as well as consult with academics from the Department of Zoology in the National University of Singapore to establish a scientific basis for health and cleanliness regulations.

The PPD found the work of Tay and his colleagues scientifically interesting, and they were encouraged to get their research published for recognition of their work and increasing the reputation of the PPD.

¹⁹⁸ Aaron Stephen Moore, *Constructing East Asia: Technology, Ideology, and Empire in Japan's Wartime Era, 1931-1945* (Stanford University Press, 2013).

Uninterested in trying to get their work published in international journals due to lack of time, Tay decided with several colleagues¹⁹⁹ from the PPD to instead establish a local publication to publish their work, with the aim to publish "original research findings and review of progress in fisheries, horticulture, animal husbandry and veterinary science and allied subjects." They named it the *Singapore Journal of Primary Industries*, and Tay published his first paper in the first issue of the journal about induced breeding of koi in 1973,²⁰⁰ explaining the process behind hormonally inducing the breeding of Japanese fancy carp in order to explore the possibilities of establishing a local koi breeding industry in Singapore.

The formation of the journal was critical for tracking the PPD's scientific research and disseminating their work to the public. The journal's existence helped foster strong collaborative relationships between Singapore's local academics and the researchers of the PPD, resulting in a proliferation of scientific knowledge generation in the ornamental fish industry in various disciplines, specifically nutrition and genetics. Most of the research conducted in the areas of general agriculture by PPD officials was published in the *Singapore Journal of Primary Industries*, and these experiments were conducted in PPD laboratories and spaces.

¹⁹⁹ Tay, F. Y. Chen, T. S. Teoh, K. C. Chou, S. J. Iswaran from the PPD were all members of this new journal, including yet more members as editor, and advisors from the National University of Singapore faculty.

²⁰⁰ S. H. Tay, "Induced Breeding of 'Koi' (Japanese Fancy Carp)", *Singapore Journal of Primary Industries* 1, no. 1 (1973): 1-6.

By allowing these officers to utilize space owned by the PPD to conduct this research in the Freshwater Fisheries Section, Sembawang, the PPD also demonstrated the priority the aquarium trade held at the time. Knowledge generated by this freedom to conduct experiments not only raised the profile and knowledge of the personnel engaged in the research, but also gave them expertise in ornamental fish rearing techniques, usually modified from food-fish rearing techniques and tailored for ornamental fish farming. Officials like George Tay thereby became experts in ornamental fish rearing and were consulted by farmers and other peoples involved in the industry, as well as allowing them to better identify issues with farm rearing techniques as pertaining to ornamental fish.

Most of the focus of the PPD's research was concerned with food products, such as fruit and meat, but aquaculture of fish for both food and ornamental purposes made a significant showing over the lifetime of the journal's existence. Many of the articles published on fish were regarding growth rates, disease and aquaculture techniques. Tay published a pair of articles in the third and fourth volumes of the journal, outlining the PPD's attempt to apply cage-net cultivation of fish to ornamental species because cage-net cultivation allowed high-density rearing of fish, writing that "the use of cage-net is confined to food fishes. No attempt had been to extend this concept of fish culture to the

cultivation of aquarium fishes."²⁰¹ In 1973, Tay and colleagues tested the feasibility of using cage-nets to rear to *Pelmatochromis kribensis*, a cichlid known as 'rainbow cichlid' in the aquarium trade. The next year, he and a colleague published a continuation of that experiment, extending the technique to three more aquarium fish: the black tetra (*Gymnocorymbus ternetzi*), serpae tetra (*Hyphessobrycon eques*) and the tiger barb (*Puntius tetragon*), investigating the effect of stocking density on the survival of these three species.²⁰² This pair of articles show the importance that the PPD was placing on the aquarium trade, by utilizing valuable, scientifically trained officials to investigate methods of improving techniques for rearing tropical aquarium fish, and thereby improving the general aquarium trade.

The constant presence of guppy and ornamental fish related research in the *Singapore Journal of Primary Industries* hint at the growth of the ornamental fish industry and an increase of collaboration between local academic researchers and the PPD staff during the 1980s. Guppies were used in several experiments to not only better understand the guppy species, but also model ornamental fish, with results applied specifically to the ornamental fish industry. In 1983 Shim Kim Fah, a professor in nutrition from the Department of Zoology in the National University of Singapore collaborated with the PPD and his colleague in

²⁰¹ S. H. Tay, P. C. Seoh, and C. S. Tan, "The Cultivation of *Pelmatochromis Kribensis* in Cage-Net in a Pond," *Singapore Journal of Primary Industries* 3, no. 1 (1975): 35-41.

²⁰² 1. S. H. Tay and C. S. Tan, "The Cultivation of *Gymnocorymbus Teinetzi*, *Hyphessobrycon callistus serpae* and *Puntius Tetrazona* in Cage-Nets in a Pond," *Singapore Journal of Primary Industries* 4, no. 2 (1976): 37-51.

NUS on nutrition in animal rearing aspects of the agriculture research in the PPD, and in particular, investigating the growth and feed conversion of guppies on artificial diets.²⁰³ He acknowledged that "[t]he tropical fish export trade in Singapore has been growing at a phenomenal rate in recent years", and that as the guppy is a "favourite ornamental fish among fish hobbyists", the guppy was chosen for the nutrition study. The nutrition study was specifically designed to investigate the protein requirements of the guppy, that is, the study was species specific. Coupled with the reasoning to choose guppies for this study because of its global popularity and thus its importance in the tropical fish export trade in Singapore, showed that the research on ornamental fish were at this point in time specific and applicable only to the ornamental fish industry, not meant for generalization to fish aquaculture at large.

Ornamental fish research continued for several years, and in 1985 started to include genetics,²⁰⁴ where Tay and colleagues from PPD investigated the Mendelian genetics of rare red colouration in grass carp. While the grass carp in this experiment was not specifically an ornamental fish, the red colouration Tay and colleagues were breeding for was not related to food in any way, but is instead related to the visual appeal of rare colours in fish. Tay et al wrote that "During one of the induced breeding experiments in early 1983, it was observed that a

²⁰³ K. F Shim and C. Y. L. Chua, "The Growth and Feed Conversion of Guppy on Artificial Diets Containing Different Levels of Protein," *Singapore Journal of Primary Industries* 11, no. 1 (1983): 24-33.

²⁰⁴ S. H. Tay, L. H. Chua and S. H. Teo, "Selective Breeding of *Ctenopharyngodon idella* (Cuvier and valenciennes) for "Red" colour", *Singapore Journal of Primary Industries* 13, no. 2 (1985): 64-69.

large number of the larvae was completely 'red' in colour instead of the usual light grey colour. Subsequently, the 'red' larvae were isolated and then raised to adults" and that the Freshwater Fisheries Laboratory of PPD were able to produce a 'red' strain of the grass carp. This reasoning was similar to that commonly attributed to koi farmers having "developed an interest in wild carp after noticing that from time to time the grey fish would have offspring that differed in colour and body patterns."²⁰⁵ This links the scientific interest in rare colouration of carp to the similar practices in breeding koi.

More detailed genetic studies were forthcoming. In 1989, Professor Violet Phang from NUS and her student Audrey Fernando published an article on the genetics of Red Tail and Blue Tail varieties of guppies,²⁰⁶ and then collaborated with the PPD to publish another genetic article on the genetics of the Yellow Snakeskin Guppy.²⁰⁷ These guppy varieties were obtained from the same local guppy farm in Tampines, Singapore. While the experiment was conducted in the National University of Singapore (NUS) campus, the researchers clearly had a good enough relationship with the farmer in order to obtain well-sorted guppy fry at a young age for most of their experiment, though

²⁰⁵ George C. Blasiola, "A History of Koi Varieties," in *Koi: A Complete Pet Owner's Manual*. (Hauppauge, NY: Barron's, 2005), 7.

²⁰⁶ Violet P. E. Phang and A. A. Fernando, "X-Linked Inheritance of Red and Blue Tail Colourations of Domesticated Varieties of Guppy, *Poecilia Reticulata* and Its Implications for the Farmer," *Singapore Journal of Primary Industries* 17, no. 1 (1989): 10-18.

²⁰⁷ Violet P. E. Phang, L. N Ng and A. A. Fernando, "Genetics of the Colour of the Yellow Snakeskin Variety of the Guppy, *Poecilia Reticulata*," *Singapore Journal of Primary Industries* 17, no. 1 (1989): 19-28.

the farmers were unable to clarify the origin of specific strains. Both of these articles were specific to the genetics of the guppy, and its significance to the farmer. In particular, the Yellow Snakeskin guppy variety was cultured specifically in Singapore, and thus could only be relevant and helpful to the Singapore based farmers. Their research was on the influence of the x-linked inheritance of red and blue tailed colouration of domesticated varieties of guppy and y-linked inheritance of the snakeskin variety – and they found that while males were the more desirable than females, depending on the kind of colours the farmer was dealing with, the females carried the desirable colouration and passed it to their sons.

Professor Phang and her students thus advised farmers to therefore "know the putative genotype(s) of the colour patterns that he specialises in breeding on his farm"²⁰⁸ in order to maximise obtaining the desired males. For Red and Blue Tail varieties of guppies, these patterns were female influenced; snakeskin varieties, on the other hand was male-linked (i.e. the male passed it down directly to his sons). While Professor Phang and her students were careful to specify that this research was specific to the Singaporean farm environment, the numerous and consistent publishing of ornamental fish aquaculture related papers in the *Singapore Journal of Primary Industries* seemed to

²⁰⁸ Violet P. E. Phang and A. A. Fernando, "X-Linked Inheritance of Red and Blue Tail Colourations of Domesticated Varieties of Guppy, *Poecilia Reticulata* and Its Implications for the Farmer," *Singapore Journal of Primary Industries* 17, no. 1 (1989): 16.

result in the same academics later crossing over to present their work in the Aquarama, in 1989 and later, which was a more general audience concerned with the ornamental fish aquaculture industry in general.

The cross-over with the Aquarama proved to be fertile. While researchers and academics were initially publishing species-specific or localized research, this research was easy to generalize in a general industry-focused forum like the Aquarama. The Aquarama became a bi-annual forum for such local research and its application to the industry. Researchers like Professors Shim and Phang who had published in the *Singapore Journal of Primary Industries* could and did choose to present their ornamental fish specific research to a very receptive audience in the Aquarama. At the very first Aquarama in 1989, Professor Phang and her students presented papers on diets and behaviours of guppies, the research itself geared towards understanding guppies' biology and behaviour in the context of a farm environment, with Audrey Fernando et al writing in a paper titled "Diets of *Poeciliid* Fishes commercially cultured in Singapore", that "livebearing fish of the family *Poeciliidae* are the major group of freshwater ornamental fishes that are commercially cultured in Singapore," with the guppy being the "predominant species reared and it accounts for 15% of the total quantity of ornamental fishes exported from Singapore." Over the next decade or so, the forum the Aquarama provided would allow space for the comfortable growth of the Ornamental Fish industry, and the

Singapore Journal of Primary Industries continued to be an excellent platform for PPD and other local scientists to publish scientific knowledge of Singapore-based aquaculture. Both the Aquarama and the journal contributed to the PPD's optimism and confidence in the health of the industry. Besides contributing to the growth of scientific knowledge, both the journal and *Aquarama* also were excellent platforms for promoting koi keeping as a hobby.

3.1.5 Understanding the social history associated with koi

The Aquarama and the space it provided to the ornamental fish industry was an excellent institution to use to monitor the growth of the koi industry in Singapore. Thanks to the prominent gift of koi from the Japanese government in 1969, koi symbolically marked the positive relationship between Singapore and Japan. In addition, fish have generally already possessed a positive association for the Chinese population for a long time, and thereby have a positive status in Chinese-majority Singapore.²⁰⁹

Koi are a very colourful, freshwater carp that have been first bred in China for food, but the colourful version that is agreed upon by casual viewers and hobbyists alike had come from Japan. While koi had

²⁰⁹ Fish appear as various motifs in the Chinese language, such as being homophones to the word abundance in proverbs like '年年有餘' (nian nian you yu, a wish for yearly abundance), and often represented visually as carp. In fact, carp themselves are fixed in the Han Chinese culture as a positive representation of education and ambition in the proverb 'carp jumping the dragon gate' (鯉躍龍門) where the behaviour of carp jumping high above the water level surface of their ponds and rivers was turned into a metaphor for a scholar passing the Imperial Examinations and thus earning a civil servant post and a future life of luxury for himself and his family.

been 'always around' in Singapore since the 1800s, they had always been the purview of the affluent, specifically those who had resources to own land and thus ponds for the koi. Goldfish also enjoy a similar status in the fish-loving Chinese society of Singapore, but they were smaller and required far less space. They could be kept in home aquariums and thus did not require land ownership. Due to the gift of koi from Japan in 1969, koi became more well-known to the public thanks to their constant display in the Istana grounds and news coverage.²¹⁰ However, the land requirement meant that only the affluent could keep koi.

The positive association koi have resonated in the Chinese social fabric, and coupled with the governmental drive to emulate Japan's economic success in the 1970s to 1980s and the restrictions of entering the hobby of koi keeping meant that only the affluent and educated population of the 1970s could keep koi. Many of this subpopulation were doctors. Dr. Tan Hwa Luck, one of the first veterinarians of Singapore, exemplified this koi hobbyist.

Dr. Tan Hwa Luck, the first veterinary of Singapore to keep koi, had become interested in fish since his boyhood, and continued to keep fish as a hobby ever since his national service. Tan decided to channel his passion for animals into becoming a veterinary instead, going to the University of Glasgow in the UK to study veterinary science. Hwa Luck

²¹⁰ Chia Potiek, "All about the birds and the fish and gracious living in S'pore", *Straits Times* (Singapore), February 27, 1970; Tan Wee Lian, "The parents of 20,000," *Straits Times* (Singapore), March 26, 1970.

graduated in 1960 and returned to Singapore to work for the then PPD for eighteen years. When he left the PPD to start his own private practice in the late 1970s, he found a reversal of his job's perception by the general public. Veterinaries were far more respected, and as he was one of the first vets in Singapore, his private practice quickly grew to provide him with the affluence needed to purchase land and keep koi.

When he started keeping koi in the 1970s, the main other serious koi hobbyists were doctors; all educated, white-collared professionals that Tan felt were very stressed in their normal work, and therefore used both the keeping of koi and the landscaping of the ponds as ways to escape the pressures of their professional lives. Serious koi hobbyists of the 1970s included Tan Cheng Bok, presidential candidate-hopeful in 2011 and other politically active and affluent individuals. Together with other doctor colleagues, Tan Cheng Bok formed the Singapore Koi Club in 1989.

Tan Hwa Luck did not consider himself a particularly serious koi hobbyist, and therefore did not join the club. However he also noted that prior to the formation of the club, there was not much information to be had on the keeping of koi. He himself had obtained koi from aquarium shops in the Orchard area and consulted contacts and friends from within the PPD such as George Tay to deal with his fish health issues. He had had a steep learning curve in dealing with his fish. However Tan Hwa Luck's story shows that in the early days of koi

keeping, individuals within the PPD were considered to be experts in the areas of koi and ornamental fish. Tay in particular had been trained in carp rearing during his work in the PPD, and had been assigned to not only take care of the Japanese koi gift, but also to investigate the scientific possibilities of rearing koi in Singapore's climate. Koi hobbyists like Tan Hwa Luck were well-educated and well-versed in understanding the scientific principles behind fish rearing, and could easily consult with PPD researchers in order to keep their koi healthy. These hobbyists were also affluent enough to obtain koi directly from Japan rather than relying wholly on local farms; Tan Hwa Luck was affluent enough to travel often to Japan in the height of his interest in koi to cultivate contacts amongst the Japanese koi breeders and import his koi directly back to Singapore. Eventually, other hobbyists were able to do so too. In the 1970s, education became linked to koi-keeping – hobbyists had to be well-educated to be affluent, and also be able to understand the necessary scientific principles in fish-rearing. The affluence meant that hobbyists like Tan were able to travel or maintain social links with Japanese breeders in order to get their fish, and they were the ones who kept the Japan-Singapore links in the ornamental fish industry.

Hwa Luck's story showed that Japanese breeders were considered the repository for koi breeding and keeping. They were the experts, and thus their husbandry practices were worth emulating.

However, as elaborated in Chapter 2, the practices could not be imported wholesale. What they learned in Japan had to be translated to fit the local climate and situation.

3.2 Industry Growth: The growth of Aquarama and the koi industry (1990s to 2000s)

Local research was necessary for the adapting of ornamental fish aquaculture to Singapore's local environment. The prominence of local research in the Aquarama helped to contribute to the growth of the Aquarama itself. In the first year of the Aquarama, direct research of the biology of ornamental fishes were grouped under "Health, Nutrition and Reproduction". Subsequent sections started to group similar research into "Genetics and Nutrition", and in 1995, started to parse out genetic research such as DNA fingerprinting away from just reproductive applications but into tagging and other molecular genetics research applications, reflecting the trend of scientific research in Singapore that was starting to shift from macro, whole-animal biology to genetics.

The shift of research started to diverge from ornamental fish specific species to fish research that could be applied to all kinds of fish aquaculture, even if the experiment models used were ornamental fish like zebrafish. By 1999, two entire sessions of research paper presentations were devoted to zebrafish development, with such topics as examining the roles of specific genes in the development of

dorsoventral patterning of zebrafish embryos,²¹¹ and the role of Hedgehog signalling in the embryonic development of zebrafish.²¹² The focus of these presentations were to elaborate the underpinnings of the role genetics play in embryonic development of fish in general, using zebrafish, a small tropical ornamental fish as a model. The basic scientific research of this nature has started to show the shift in focus away from ornamental fish in specific to fish in general, and possibly as a model to represent vertebrates at large.

Within ten years, scientists working closely with the ornamental fish industry in terms of disease management, breeding biology and other aquacultural practices and generating scientific knowledge within these areas slowly shifted away from being species and industry specific, turning towards the adopting of ornamental fish as small useful models for fish research in general. While the Aquarama continued to run in Singapore till 2015, many local scientists no longer presented their research in the Aquarama, and presentations at the Aquarama started to focus more on legislative and market issues rather than science. Singapore's Aquarama from 1999 on-wards had declined as a forum for the sharing of ornamental fish science, academics starting to retire and their replacements focusing on more generalised science.

Koi's presence was also growing in the Aquarama forum and

²¹¹ M Hild et al., "The Roles of BMP2B, BMP7, SMAD1 and SMAD5 during Early Dorsoventral Patterning of the Zebrafish Embryo," in *Aquarama Conference Proceedings* (6th Aquarama 1999, Singapore, 1999), 55.

²¹² P. W. Ingham et al., "Hedgehog Signaling and Somite Patterning in the Zebrafish," in *Aquarama Conference Proceedings* (6th Aquarama 1999, Singapore, 1999), 58.

with it, Japanese sources of expertise and knowledge. Due to the upward trend of demand just previous to the 1980s, koi started to become prominent and popular enough in Singapore's market that the first conference proceedings of Aquarama included a talk from Kamihata Shigezo, president of Kamihata Fish Industries of Japan, on the appreciation of koi and the 'evolution' of koi. That is, the fixed-ness of particular breeds of koi.²¹³ Starting with the first publication on koi by George Tay in the *Singapore Journal of Primary Industries*, koi started to show itself in the PPD's interest as a potential industry niche. The public was definitely interested in koi, as evidenced by the prominent placement of Kamihata's presentation in the Hobbyist section of Singapore's first Aquarama. Koi continued to show up in subsequent Aquaramas.

Koi was initially imported from Japan into Singapore either by individuals or small aquarium dealers in high-end Orchard Road. This was the location of the first glimpse of koi readily available to the public by people such as Pay Bok Seng. His interest piqued, he quickly made friends with several people within the PPD who were involved in the Singapore's Industrial Farm. It might not have lasted long, but for the three years it was running, several people including George Tay were involved in breeding and culturing koi there. Pay was able to obtain koi

²¹³ Shigezo Kamihata, "An Appreciation of Nishikigoi in Terms of Their Evolution," in *Aquarama Proceedings: First International Aquarium Fish and Accessories Conference*, vol. 1 (Aquarama, Singapore, 1989), 172-77.

from the IF before it became defunct. From 1986 to 1989, as his farm had to shift between Lim Chu Kang and then to Tampines due to expropriation of the farmland by the PPD and HDB, he started rearing koi in his farm, switching from rearing tropical ornamental fish in general such as cichlids and discus to a monoculture of koi.

The move to breeding and importing koi directly from Japan with a focus wholly on koi gave Pay a huge advantage over the dealers he'd seen in Orchard Road. Dealers such as these could only import small numbers of koi, as their premises were literally shop-fronts without much space for large numbers of koi. The koi size and breeds were thus limited. Pay and other farmers, when they had the land, were able to import koi numbering in the hundreds, and more than a handful of different koi breeds. Pay thus could not only out-compete the small dealers in Orchard Road, he could meet an increased demand.

And buyers were definitely demanding. In the 1990s, the demand for koi surged; the establishment of the Singapore Koi Club in 1989 gathered hobbyists, allowing them to form a bloc of centralised knowledge as well as demand. They were able to collectively get the power to start ordering magazines from Japan such as *ZNA Nichirin Magazine* (Zen Nippon Airinkai), and order koi from dealers such as Pay. More importantly, they were able to share experiences and gain understanding of how to keep koi, so that Hwa Luck's problems he had had with having to experiment to get the results he wanted through

trial-and-error was minimized.

Information and knowledge from Japan was established with the Singapore Koi Club and farmers' ties to Japanese breeders, and the information passed along these ties and magazines were the start of aquaculture practices learning from Japanese breeders. The presence of the Singapore Koi Club legitimized the hobby of koi keeping, and newer hobbyists could still become openly hobbyists even if they did not join the club. Later hobbyists like Johnson Lee was able to enter the hobby without much issue, since there were established figures of centralised knowledge.²¹⁴ In the mid-1990s, hobbyists like Tjo Kwe In started to attempt to turn their hobby into a business, using their knowledge and contacts to further themselves into the industry.

As Japanese farmers were considered to be experts in koi husbandry and farming, Tjo went to Japan and apprenticed himself to a farmer in order to learn some of this expertise. He claimed that it was difficult as the apprentice-ship style was not what he was used to; the farmers did not explain fully why they performed certain practices and he had to observe and deduce the logic for himself. However when he returned, he then had a reputation for being very knowledgeable in identifying good quality koi, and thanks to the apprenticeship, had established by good connections with Japanese farmers.²¹⁵ Tjo then started organising koi rearing parties for hobbyists like Johnson and

²¹⁴ Johnson Lee, interviewed by author, Singapore, 19 May 2016.

²¹⁵ Tjo Kwe In, Interviewed by author, Singapore, 25 May 2016.

others, where he would make an agreement with a good farm like Sakai Farm, who would provide them with tosai (young koi before one year of age) and they could choose a koi as their own, and over time would take pictures at Tjo's farm to see how the koi grow. This was an event that Johnson and other hobbyists counted as less like gambling and more educative. They were supposed to choose koi they thought were prize winning, and then over time would be able to see how the fish grew and the patterning developed. Doing so allowed them to develop a better eye for judging the potential of koi. This practice was an example of how koi practices in Japan was transmitted but adapted in the form of education for the Singapore audience.

By mid 1990s, the craze for koi hit its peak. Koi required space and upkeep. While keeping the koi alive was relatively easy with a decent pond and filter water set up, keeping the koi in the optimum pattern and beauty was far more taxing and demanding on their keepers. While it was difficult to give up this commitment, since, as Johnson said, "you can give up a tank, but can you give up a hole in the garden?" especially after one had made physical and structural changes to one's home, but it was still not easy to continue. Koi were expensive to import, especially the larger, more beautiful ones that were more likely to win prizes and praise. Large koi that were 80cm or larger were incredibly expensive, going for tens of thousands of dollars, or would require years and effort to rear a smaller koi to that size. A competition

worthy koi once cost SGD 250,000 in 1997.²¹⁶ Large competition worthy koi was an investment, either in time and effort or economically.

Maintaining Japanese koi in the tropical climate with Singapore's particular water conditions was also a lot of hard work. As elaborated in Chapter 2, water parameters needed constant monitoring in order to prevent a decline in the koi health and appearance. For some hobbyists, this meant keeping the pond water chilled, which could cost up to the rent of a single room.²¹⁷ The high monetary expenses of meant that there was a drop off of hobbyists starting in the late 1990s, early 2000s. For others, this meant trying to modify the hardness of water with shell or other calcium additives to soften the water to be more like Japan's.²¹⁸ However, some hobbyists found that difficult to maintain, and stopped the practice.

Furthermore, fewer young people were getting into koi. Johnson remarked that his young son was not interested in fish, seeing them as just his father's hobby, and was more interested in contemporary electronic devices and games rather than fish. Hwa Luck himself started losing interest in koi because his interest turned toward ecological sustainability. Koi demanded fresh clean water constantly and could not be eaten, while other kinds of fish like tilapia were meant for food, and

²¹⁶ Francis Ong, "This koi cost a whopping \$250000," *Straits Times*, April 13, 1997.

²¹⁷ Data from the interview on import event. While my interviewee, who declined to be named, quoted SGD500 as his monthly cost of chilling the koi's water, he was using today's cost of living, rather than earlier. Currently, rent of a single-room in Singapore would be SGD600 to 800 in 2017. While the cost of utilities twenty years ago would not be the same, this shows that power costs of maintaining koi were still not insignificant.

²¹⁸ Jerome Ng, conversation with author, March 25, 2016.

thus could be maintained in a less demanding fashion. Hwa Luck started to phase out koi by not buying new ones and letting the old ones age and die, and left the hobby. Cheaper "poor quality" koi were everywhere, in hotel lobbies and any building that wanted to have a water feature. Their common-ness in the normal person's mind seemed to decrease their desirability. Young people were increasingly not able to obtain landed property as easily as men like Johnson and Hwa Luck were able to in their time. Jerome's parents were able to buy a large house in 1980 for SGD 560,000; the same property is now valued at SGD 3million in 2017, much higher than inflation (SGD 1.2 million) due to scarcity.

While there was a decline in new membership of the hobby, there was still a reasonable market remaining. The ornamental fish industry was still growing steadily, climbing from USD 43 million to in 1998 to over USD 60 million in 2006. Well-established ties to Japan and proven market interest in koi from the receptive audience in the Aquarama, meant that farmers such as Pay able to import koi directly from Japan. Several members of the Singapore Koi Club and the koi hobbyist community such as Tjo Kwe In and Max Ng, felt knowledgeable enough of koi's biology and rearing to transition from being purely hobbyists to attempting to make a living from koi in 2000. By drawing on similarly cultivated contacts in Japan and knowledge learned from observation of Japanese breeders, these hobbyists became koi farmers and dealers

themselves. In doing so, these individuals such as Max Ng and Tjo Kwe In managed to establish themselves as experts in koi husbandry and culturing, setting up their respective farms in 2000, indicating the maturity of the koi industry. The koi industry continued to grow, if slowly, till 2006.

3.3 The Turning Point: KHV (2006)

In 2006, the PPD, now renamed Agrifood and Veterinary Authority (AVA) published a two page spread on the appearance of Koi Herpes Virus (KHV) in Singapore. The AVA had been aware of the occurrence of KHV in other countries since July 2003. Corporate reports published by AVA between 2003 and 2004, where officials from AVA were conducting "continued surveillance" of KHV²¹⁹ and initiated some measures when there was an outbreak of KHV in 2003 in Japan. These measures were "compulsory inspection, testing and quarantine of all koi consignments imported from Japan", which were the same as applied to koi imported from Indonesia, where a disease outbreak termed 'koi mass mortality syndrome' occurred in June 2002.²²⁰ These preventive measures were not yet implemented on the farm level however.

When the disease showed up on Singapore's shores in 2006, these measures included testing of koi on Singaporean farmers, and when KHV was found, the farm was shut down and all livestock was

²¹⁹ "Agri-Food and Veterinary Authority of Singapore FY2002/03 Annual Report", Corporate Report (Singapore: Agrifood and Veterinary Authority, 2003), page 35.

²²⁰ "Agri-Food and Veterinary Authority of Singapore FY2003/04 Annual Report", Corporate Report (Singapore: Agrifood and Veterinary Authority, 2004), page 34.

culled in order to prevent the KHV from spreading. These disease management measures also involved farmers having to put their farms on hold while the AVA officials tested their stock. Farmers like Tjo Kwe In had had to halt his farm operations for months waiting for AVA officials to test their fish. They expressed their impatience with phrases like "had to wait for them to come test, but the AVA vet was elsewhere testing for swine flu!"²²¹ Direct testing of koi on farms disrupted the working of these farms, and interrupted the industry significantly, preventing farmers from continuing their business of selling and importing as they had to prepare for these new measures. Unlike the previous decades of close cooperation and communication between farmers and government officials, the implementation of preventive measures due to KHV seemed to indicate a rupture in the communication between these two social groups in 2006.

These measures were all in an effort to first prevent disease from entering Singapore, and then when the first instances did occur on Singapore farms, to prevent from further spreading. The short appearance of KHV had a huge and devastating impact on the koi industry and subsequently on the ornamental fish industry. It only took two years for this event to impact the ornamental fish industry. The ornamental fish industry went from being worth USD 69million in 2008 to USD 59 million in 2010, and continued dropping to USD 42 million in

²²¹ Tjo Kwe In, Interviewed by author, Singapore, 25 May 2016.

2016, the same value it was in 1999, seventeen years ago²²² (See Figure 3.6). Strong and rigid implementation of these disease control measures affected not only koi, but any fish that were in contact with the water that koi had been in, and conducting importing and exporting businesses in Singapore meant that restructuring of the farms had to occur to prevent water contamination between different species, and even between different shipments of koi – that is keeping the koi bred on Singapore farms separate from koi imported recently from Japan. Pay for example had his farm inspected by farmers from Japan who expressed shock at his large farm and that it was necessary for him to device ways to cordon off sections of his breeding koi, koi imports, and koi he was hosting from other koi owners. These restructuring measures were not easy on farmers, having to make these changes at their own expense, with reduced income thanks to the delay in testing for disease by the AVA.

3.4 The decline: 2006 till present

After the implementation of new regulations of importing and breeding koi, the importing of koi dropped sharply. Breeding and importing/exporting were now separated into two separate licenses, and coupled with the difficulty in meeting requirements for importing, koi importing for many farmers became difficult to maintain. The

²²² Figures of the Singapore's ornamental fish industry value was taken from the United Nations Commodity Trade Statistics Database.

ornamental fish industry in general also saw declining profits, and the possibility of losing its global edge,²²³ after the KHV event. In general however, the biosecurity issues with the industry had resulted in a sharp increase in regulations governing the aquaculture industry. Farmers also were finding it hard to renew land-leases from the government for their ornamental fish farms. While this is not covered in my analysis, this tension hints at being a result of the change in government's focus, where food fish farming is prioritized over ornamental fish. By 2013, fewer ornamental fish were able to renew their farm leases and had to close the next year.²²⁴

In 2010, the AVA introduced a new newsletter titled *Ornamental Fish Newsletter*, but the newsletter only lasted five issues, ceasing in 2015. This indicated a lack of interest in the ornamental fish industry, despite the ornamental fish industry being touted as the global leader in ornamental fish exports. Jessica Lim from *The Straits Times* reported that the percentage of global ornamental fish export value Singapore's industry had in fact decreased from 25% in 2000 to 17% in 2013²²⁵ and continued to decrease. Ornamental fish farms switched to farming marine food fish, and sought AVA assistance²²⁶, which the koi industry reflects. Koi fish farms decreased dramatically to the current handful

²²³ Jessica Lim, "Rough seas ahead for Ornamental fish exporters," *Straits Times*, January 14, 2013;

²²⁴ Jessica Lim, "13 ornamental fish farms in Pasir Ris to close by the end of 2014," *Straits Times* (Singapore), January 14, 2013.

²²⁵ Jessica Lim, "Major farms switching to food fish," published in *The Straits Times* (Singapore) on July 18, 2015.

²²⁶ *Ibid.*

present today, and even these farmers were turning to other avenues of income besides rearing only koi. Pay of Nippon Koi Farm started to farm marine food fish²²⁷ to attempt to gain government subsidies²²⁸ and food fish now comprises thirty percent of Max Koi Farm's revenue.²²⁹ Despite the switching of ornamental to food fish aquaculture, the tension between the aquaculture industry and State resources still existed, as "Singapore has limited land with competing needs", and therefore putting further pressure on the fish aquaculture industry as a whole.

Other koi farmers turned to other avenues – such as Zion Koi farm's owner Tjo Kwe In using his knowledge in the construction of koi ponds to consult on the building of other water features around Singapore. Diamond Koi Farm's owner reduced his business by reducing his import volume; only importing a few individual fish when customers placed orders with him, cutting down on his maintenance costs and allowing him to reduce the amount of land required to maintain these fewer fish.

Many local academics were no longer studying ornamental fish – while certain ornamental fish like zebra fish and merdeka are still currently being used in genetics studies, these studies were not applied to the ornamental fish aquaculture and instead were meant to further

²²⁷ Jessica Lim, "Koi farm owner changed tack - and did it his way," *Straits Times* (Singapore), July 18, 2015.

²²⁸ Pay Bok Seng, interview with author, 2015.

²²⁹ Jessica Lim, "Major farms switching to food fish," *Straits Times* (Singapore), July 18, 2015.

genetics understandings. The *Singapore Journal of Primary Industries* was no longer being published. With George Tay's and his peers' retirement, few of the new officers were keen on continuing to keep the journal and publish their work, despite the benefits of being recognized regionally for their work.²³⁰ The short-lived *Ornamental Fish Newsletter* failed to be a viable replacement for the *Singapore Journal of Primary Industries*, nor could it help drum up interest in the Aquarama. The Aquarama also exhibited a decline of attendance, becoming less and less a viable forum for academic presentation and discourse. Without a viable forum and a local publishing platform, collaboration between the AVA researchers and the local academics decreased. The final issue of the *Singapore Journal of Primary Industries* was published in 2006, and the last Aquarama was held in 2015.

Further issues plague the koi industry: the personal costs for koi keeping remained high, and land-scarcity meant that the costs of housing that included land increased markedly. Hobbyists were not able to afford property that the previous generation could. Koi too are easily obtainable globally, rather than having to pass through Singapore's farmers for a quality-assurance. When previously, in the 1980s Singapore was one of the few places to obtain koi, currently there are many huge farms in the nearby region such as Malaysia, which can breed and rear koi with lower restrictions than Singapore's biosecurity

²³⁰ Conversation with an AVA officer who declined to be named, May 15, 2015.

regulations. While hobbyists consider that the koi bred outside of Japan to be of poorer quality, large farms in Malaysia could supply bulk volumes of cheap koi. This was ideal for industries like the hotel industry which only wanted to have a water feature with a few colourful fish in them, and were easy to replace in bulk if they died. General fish shops in Singapore could easily supply koi at less than SGD 50, so that casual fish owners can keep a few fish for low monetary investment.

3.5 Conclusion: Recreation of Japan's Environment

The history of Singapore's ornamental fish industry and political relationship with Japan made translation of Japan's environment and into aquaculture practice for Singapore's koi hobbyists and farmers much easier and enabled the growth of Singapore's ornamental fish industry. Singapore's ornamental fish industry had an excellent base to start from during the 1960s, with many villages rearing and breeding various ornamental fish, and thus local expertise, especially with tropical ornamental fish. Singapore had a generally good reputation for healthy ornamental fish, with a high survivorship of fish when they were exported overseas. The ornamental fish industry eventually developed vibrant and active forums for scientific knowledge and exchange, resulting in the strong collaboration between local scientists and government researchers. This fed back into the forums – Aquarama and the *Singapore Journal of Primary Industries* – becoming sources of

scientific knowledge for local hobbyists to obtain expert help and information. The Aquarama was also the place where many hobbyists were exposed to koi. Both the forums were platforms during which the translation of scientific knowledge of ornamental aquaculture was translated into aquaculture practices for hobbyists and farmers.

Japanese koi aquaculture practices were seen as important in maintaining koi. Many farmers were also the first to import koi out of Japan into Singapore, bringing with the fish its diseases and the knowledge associated with them. Their vernacular knowledge of koi was considered necessary to incorporate into koi cultivation in Singapore. By the 1990s, demand for koi increased due to Singapore farmers being the few avenues of obtaining koi, and the hobby was strong enough to have a dedicated koi club and several hobbyists with expertise in koi husbandry who eventually set up their own farms in 2000. Singapore's identity of good quality also became enmeshed with ornamental fish and by extension, export of healthy koi. After the KHV incident in 2006, however, stringent biosecurity measures implemented by the AVA was one of the factors leading to the downward turn of the koi industry. Coupled with a low recruitment of new koi hobbyists, farmers were not able to rely on koi farming as full-time employment, leading to the current decline of the ornamental fish industry today.

Maintaining and reproducing koi was the driving force in learning aquaculture practices from Japan. These practices were not just

imported wholesale but instead were adapted to the Singapore environment in order to recreate the Japanese environment for koi. The vernacular knowledge produced by Japanese farmers was considered by Singapore hobbyists and farmers necessary to translate, both linguistically and in terms of practice in order to change and adapt aquaculture practices in Singapore to recreate Japanese conditions for koi in Singapore, and thereby aid successful translocation of koi. However, scientifically based knowledge was not the only kind of knowledge transferred from Japan. Other practices that had a far more distant relationship to scientific knowledge was imported as well. In particular, this was the transferring of disease management of KHV protocols from Japan. In order to understand the impact of Japan's aquaculture practices in the wake of KHV on Singapore's koi aquaculture practices, the next chapter (Chapter 4) will elucidate the emergence of KHV and how it was made intelligible. Making the disease intelligible was important for Japan's government to institute disease management protocol, which in turn was translocated and adapted into Singapore's aquaculture practices (Chapter 5).

Chapter 4: The Emergence of KHV (1997 to 2006)

In 2005, Minamoto Toshifumi, Honjo Mie, and Kawabata Zen'ichiro from the Research Institute for Humanity and Nature in Kyoto, Japan, published a paper detailing the seasonal distribution of Cyprinid Herpesvirus 3, known informally as Koi Herpes Virus (KHV), in Lake Biwa, Japan. The mild 'seasonal' term masks the fear and worry that surrounded this virus, for it was a "novel fatal disease of fish" which had been first reported in the 1990s and spread rapidly globally.²³¹ When it first appeared in Lake Kasumigaura, Japan, it quickly spread throughout Japan's freshwater systems. The high mortality rate of this new disease launched an almost immediate response into the research of this virus, for it affected common carp, a large product of food fish aquaculture in both Europe and Asia, and the colour morph of the same species, ornamental koi. With a high lethality of the infected fish, the KHV was a galvanising force in the study of a new disease against the backdrop of an intersection of economics, social interactions, security concerns and even climate change. In an effort to uncover first the identity of this novel disease that occurred in the late 1990s, a group of scientists developed a polymerase-chain reaction (PCR) tool for distinguishing it from other carp viruses became the diagnostic tool for the presence of the virus. The PCR tool became the

²³¹ Toshifumi Minamoto, Mie N. Honjo, and Zen'ichiro Kawabata, "Seasonal Distribution of Cyprinid Herpesvirus 3 in Lake Biwa, Japan", *Applied and Environmental Microbiology* 75, no. 21 (November 2009): 6900-6904.

main test that stood between economic continuity and the culling and loss of the koi in Japanese farms. The diagnostic test became incorporated into protocols meant to prevent and control spread of koi disease and eventually the regular production cycle of koi in Japan. Chronologically, events of this chapter took place almost a decade before the first appearance of KHV in Singapore. It is therefore necessary to analyse the scientific knowledge that was generated in first the characterisation of the KHV virus, then the diagnostic process and procedure for this disease and thereafter the procedures that were developed in Niigata to guard against KHV once it was made known and visible. As Niigata Prefecture is the main area of koi production in the world, biosecurity measures on the part of the Niigata Prefecture officials influence the biosecurity practices in other parts of the world, such as in Singapore. Controlling biological threats and protecting a specific population from the threats via a system of regulations and policies that control and regulate the movement of the biological threats is the aim of biosecurity.²³² 'Biosecurity' comes from the term 'security', and is specifically concerned with national sovereignty and safety threatened by biological entities. Diseases and other biological organisms that could adversely impact a nation's various industries

²³² Koblenz, Gregory D. "Biosecurity reconsidered: calibrating biological threats and responses." *International security* 34, no. 4 (2010): 96-132, Kamradt-Scott, Adam, and Colin McInnes. "The securitisation of pandemic influenza: framing, security and public policy." *Global public health* 7, no. sup2 (2012): S95-S110,

such as agriculture and ecological purity, and also came under the purview of biosecurity.

In this chapter I shall analyse the confounding rise of Koi Herpes Virus (KHV) as it was first identified in Germany, and then subsequently characterised and distinguished from other carp viruses in the US. I shall elaborate on the process on which KHV was translated into made legible via scientific investigation and how KHV was used to generate scientific knowledge of its relationship with koi. As a result of this process, I shall also analyse how this scientific knowledge was further translated into a disease management protocol and how it affected Japan's aquaculture practices.

Dr Ronald Hedrick and his research group from the USA was the main force in starting the investigation and characterisation of the virus, and when the virus impacted Japan, Niigata's Inland Freshwater Fisheries Experiment Station officials became the forefront in researching and developing biosecurity regulations to try to manage KHV even before it appeared in Niigata. The virus and its virulence had a strong impact on both the common carp food aquaculture industry and the koi ornamental fish industry. Its rapid global spread also meant that it quickly became an international concern, and in countries such as Japan where both common carp and koi are important industries, KHV instigated international action. While I focused mainly on the effects KHV had on the koi industry in Niigata Prefecture, Japan, the research

conducted on the virus in Israel, EU, and the USA was critical in the shaping of the management practices on an international scale. Prior to the identification of KHV, koi were allowed to move freely on the global scale. After the international report of KHV's effects, international regulation of koi's movement came into play, using health certificates of the fish as a passport to enter or leave a country. While the knowledge generated by scientists in the EU, USA and Israel as a result of trying to characterise KHV was available to both Japan and Singapore, the way regulation policies were formed and informed by their different social circumstances resulted in very different outcomes. The development of a diagnostic tool to detect the presence of KHV was integrated into Japan's koi management practices, and these practices were available to other countries for adaptation. The interpretation of this scientific knowledge and how it came to be implemented into animal control protocols in Japan is important in understanding how Singapore learned and adapted this protocol for Singaporean use. The forms of knowledge that scientists had generated were important in understanding how they were translated from scientific knowledge into policy and practice, and integrated into farm practices and protocol.

Experimentation on KHV was geared primarily to first identifying and characterising it – KHV first appeared as a strange new disease that resulted in mass mortality. The use of models of other carp herpes viruses by Hedrick and his fellow scientists in the early 2000s led

quickly to their "making the enemy visible."²³³ The newness of this disease meant that the KHV-carp system had "dynamic instability,"²³⁴ which made it productive in research, according to Rheinberger's framework of experimentation in science.²³⁵ Much of the scientific research that emerged from this system, however, assume that KHV and fish exist in a natural environment. However, as I shall show in the rest of the chapter, koi and its diseases did not exist in a natural environment, and instead the human intervention in rearing the koi could well have an impact on the activity of the disease. The interaction of fish and virus thus became critical in understanding the dynamic that "emerge[d] amid intimate entanglements with other species".²³⁶ The KHV-koi system thus neglects to take into account the human factor in this system. Not only are humans attempting to intervene and prevent the virus from infecting its host, other environmental changes that humans make around the fish affect the ability of the virus to infect the host. In this chapter, I intend to show how in the pursuit of knowing KHV by generating scientific knowledge, policy makers and regulation officials translated this knowledge into policy and protocol, creating a set of protocols or practices that could be taken and used by other people.

²³³ Angela NH Creager, "The War against Polio", *The Life of a Virus: Tobacco Mosaic Virus as an Experimental Model, 1930-1965* (University of Chicago Press, 2002), 184.

²³⁴ Angela NH Creager, "That "Whirligig of Science", in *The Life of a Virus: Tobacco Mosaic Virus as an Experimental Model, 1930-1965* (University of Chicago Press, 2002), 139.

²³⁵ Hans-Jörg Rheinberger, "Experiment, Difference, and Writing: I. Tracing Protein Synthesis", *Studies in History and Philosophy of Science Part A* 23, no. 2 (1992): 305-331.

²³⁶ Eben Kirksey, "Introduction", in *Emergent Ecologies* (Durham: Duke University Press, 2015), 5.

4.1 Making KHV intelligible

The Koi Herpes Virus (KHV) had been first reported in Israel, several European States and the USA. 1997 and 1998 marked the first several puzzling cases of mass mortality of koi carp in Germany. The highly lethal occurrences warranted investigation, as *Cyprinus carpio* was both hugely expensive ornamental fish (koi) as well as an important food source as common carp. The two visually distinct breeds of carp turned out to be highly susceptible to the as yet unnamed disease.²³⁷ The unknown disease not only impacted food sources and an expensive commodity, it was not even known what this disease causing agent was, let alone whether it was native or not. Without this information, protecting the carp against it was impossible. Bretzinger and his colleagues took the first step in identifying this unknown disease by formally characterising the symptoms as "moderate to extensive epidermal lesions, gill necrosis and enophthalmus" with the fish having "pale internal organs and an enlarged anterior kidney" when examined anatomically.²³⁸ The dead fish had very few ectoparasites, and while they displayed similar symptoms they had different opportunistic bacterial infections, which, to Bretzinger and colleagues meant that they could eliminate the possibilities of the infection being bacterial and

²³⁷ A. Bretzinger, T. Fischer-Scherl, M. Oumouna, R. Hoffmann, and U. Truyen. "Mass Mortalities in Koi Carp, *Cyprinus Carpio*, Associated with Gill and Skin Disease," *Bulletin of the European Association of Fish Pathologists* 19, no. 5 (1999): 182-85.

²³⁸ A. Bretzinger et al., "Mass Mortalities in Koi Carp, *Cyprinus Carpio*, Associated with Gill and Skin Disease," *Bulletin of the European Association of Fish Pathologists* 19, no. 5 (1999): 182-85.

protozoan. Using transmission electron microscopy (TEM), Bretzinger et al found traces of virus-like particles in the epithelial cells of the fish's gills, and led to the suspicion that the cause of this mass mortality events was a viral infection.

At the same time, similar outbreaks occurred in the USA and Israel in 1998, the outbreaks in both countries happening after koi returned from a koi show, which instigated an investigation by Dr Ronald Hedrick from Department of Medicine and Epidemiology, School of Veterinary Medicine, University of California, USA and other lab-members to identify, isolate and characterise the disease causing the epidemics. Dr. Hedrick was interested in the disease because of its virulence, noting at first how the outbreaks in the USA and Israel looked similar to that of the sole characterised carp herpes virus (CHV), which had first characterised with another colleague in 1989. Hedrick et al isolated the new pathogen as a herpes virus in 2000²³⁹ and suggested that "herpesvirus may be one factor contributing to the mass mortality of koi (and perhaps common carp) observed in recent outbreaks in the USA and Israel."²⁴⁰ Hedrick et al obtained fish from producers and retailers in the mid-Atlantic regions of the USA and from Israel for their attempt in isolating and characterising the pathogen causing mass

²³⁹ R. P. Hedrick, O. Gilad, S. Yun, J. V. Spangenberg, G. D. Marty, R. W. Nordhausen, M. J. Kebus, H. Bercovier, and A. Eldar, 'A Herpesvirus Associated with Mass Mortality of Juvenile and Adult Koi, a Strain of Common Carp,' *Journal of Aquatic Animal Health* 12, no. 1 (1 March 2000): 44-57.

²⁴⁰ R. P. Hedrick et al., "A Herpesvirus Associated with Mass Mortality of Juvenile and Adult Koi, a Strain of Common Carp," *Journal of Aquatic Animal Health* 12, no. 1 (1 March 2000): 45.

mortality amongst koi in these regions. In Hedrick's lab, the examination of naturally infected or experimentally infected fish was similar to that as performed by Bretzinger and colleagues in 1999 in the EU: first the gross external examination of the fish and tissue-samples, paying particular attentions to the lesions found on the skin and on the internal organs. Hedrick and his colleagues examined the fish for bacterial cultures from the kidneys of the fish, and then also took samples from brain, gill, skin, liver, kidney, spleen, and small intestine to isolate viruses from these tissues.

Hedrick and colleagues' efforts in meticulously laying out the virus' pathology was mostly in an effort to determine whether the virus was more virulent and lethal variant of already extant and characterised viral diseases. What was stunning about this potential new virus was that unlike other carp viruses which tended to target only younger carp, this new virus was lethal to all ages of carp.²⁴¹ It was also highly specific to only the koi species, and no other species of carp. It was necessary to make this virus intelligible in order to attempt to control it.

The importance of the behaviour and appearances of the koi were what marked the start of an epidemic: Hedrick et al reported that the fish in the USA were "were lethargic, moderately disoriented, and had pale and irregular coloration of the skin and gills. The bases of fins were

²⁴¹ Ronald P. Hedrick et al., 'Initial Isolation and Characterization of a Herpes-like Virus (KHV) from Koi and Common Carp', *Bulletin of Fisheries Research Agency Supplementary 2* (2005): 4.

congested, but most fish had no evidence of skin ulcers or hemorrhages²⁴² ten to fourteen days after returning from a koi show, and all sizes of koi were affected. The implication of all sizes meant that all ages of koi were susceptible to this at the time unknown disease. In Israel, farms from the Mishor Hahof region (northwest coast) and Jordan Valley reported huge losses of koi and common carp. Again, behaviour was one of the first signs of the disease - "affected fish were lethargic then suddenly hyperactive, followed by a complete loss of equilibrium before death". Physical appearance did not seem to be particularly identifying - in Israel the skin of the koi were reported to be "patchy but transient"²⁴³ due to excessive or insufficient amounts of mucus produced. The most common physical appearance change was the necrosis or tissue-death of gills, identified by irregularly coloured gills. Hedrick et al noted that *Ichthyobodo* sp were found in large numbers in samples of both the USA and Israel infected fish, but the protozoan parasite was not found in every fish sample. Lesions and other internal signs of damage to the internal organs were similarly inconsistent, and bacterial cultures were a mixed group of different species, and again, inconsistently found in across all individuals of fish in the study.²⁴⁴

²⁴² R. P. Hedrick et al., 'A Herpesvirus Associated with Mass Mortality of Juvenile and Adult Koi, a Strain of Common Carp', *Journal of Aquatic Animal Health* 12, no. 1 (1 March 2000): 47.

²⁴³ Ibid.

²⁴⁴ R. P. Hedrick et al., "A Herpesvirus Associated with Mass Mortality of Juvenile and Adult Koi, a Strain of Common Carp," *Journal of Aquatic Animal Health* 12, no. 1 (1 March 2000): 48.

Behavioural and physiological symptoms were ambiguous and inconsistent, stymieing normal disease diagnosis. The only consistent agent across all the koi samples from both USA and Israel were found in the viral tests. In these tests, Hedrick et al tested for cytopathic effects of extracts from the various body and organ tissues from the infected koi on koi-fin cell lines (named as KF-1), which are the changes of the host cells due to a viral infection, and found that the type and onset of cytopathic effects from koi samples were the same across both USA and Israel koi samples.²⁴⁵ Hedrick et al named this particular virus Koi Herpes Virus (KHV), and distinguished it from the Carp Herpes Virus (CHV) or *Herpesvirus cyprini* as the KHV had a different cytopathic effect from the CHV. They had obtained CHV samples from H. Fukuda, Tokyo University of Fisheries, Japan. And then Hedrick et al propagated the CHV virus in their KF-1 cell-lines under the same conditions as for the KHV samples. Further tests using CHV-antibodies confirmed that KHV was a completely different virus – the anti-CHV serum that Hedrick et al obtained from the same Fukuda of Tokyo University of Fisheries only reacted with antigens from KF-1 infected with CHV, and had no response to antigens from KF-1 infected with the new disease. Hedrick *et al.* tested transmission and exposure of the new disease by injection and bath-exposures, and all infected koi had similar systemic lesions as the koi from the first outbreaks in USA and Israel, and

²⁴⁵ R. P. Hedrick et al., "A Herpesvirus Associated with Mass Mortality of Juvenile and Adult Koi, a Strain of Common Carp," *Journal of Aquatic Animal Health* 12, no. 1 (1 March 2000): 48-51.

showed no apparent difference in infected symptoms from the viral extracted from USA or Israel fish.²⁴⁶

From this extensive study, Hedrick *et al.* concluded that the disease was not a more virulent form of previously studied herpes viruses; other diseases like CHV was age-related, and older fish were not affected, while KHV was apparently indiscriminate in infecting all ages of koi. Most importantly, the antibodies produced by infected KF-1 tissues by CHV and KHV were different. They also concluded that the KHV-U (KHV from USA samples) and KHV-I (KHV from Israel samples) were not different as they produced similar anti-gen reactions, and were different from CHV infected KF-1. Hedrick et al did point out that KHV was similar to another herpes virus, but KHV specifically and exclusive in infecting only koi, and not other carp species, including goldfish as "a preliminary infection trial in [their] laboratory suggests that 2-year-old goldfish are resistant to virus induced mortality."²⁴⁷ The report was the first in establishing the koi herpes virus distinct from other previously characterised viruses of carp, unique and terrifying in its specificity of *Cyprinus carpio*, both the common carp and its colourful ornamental breed.

Hedrick et al had speculated that part of the reason why this disease had spread so widely by 2004 was "through the largely

²⁴⁶ R. P. Hedrick et al., "A Herpesvirus Associated with Mass Mortality of Juvenile and Adult Koi, a Strain of Common Carp," *Journal of Aquatic Animal Health* 12, no. 1 (1 March 2000): 51

²⁴⁷ R. P. Hedrick et al., "A Herpesvirus Associated with Mass Mortality of Juvenile and Adult Koi, a Strain of Common Carp," *Journal of Aquatic Animal Health* 12, no. 1 (1 March 2000): 56.

unregulated movements of koi, although other unknown mechanisms may also be involved". However the term koi used here meant the colourful versions of *Cyprinus carpio* – the initial populations of fish that Hedrick' lab had examined were koi which had returned from a koi show or were in a koi farm. Unregulated movements by the koi were less the koi's movements and more that people were moving these koi all over the world – and the koi were infected by exposure to other infected koi. The most interesting fact about the virus was that Hedrick lab had discovered that the rate of viral replication was highest in the 20 – 25 °C, and at higher temperatures like 30 °C or lower like 4 °C showed no growth.²⁴⁸

Hedrick et al distinguished the new virus from other carp viruses such as CHV-1 or *Cyprinid Herpesvirus* based mainly on the fact that anti-CHV-1 antibodies failed to react with KHV in immunofluorescence assays²⁴⁹ and his lab later discovered genetic differences as further proof of the differences between KHV and other carp herpes viruses by comparing polymerase chain reaction (PCR) to first amplify the DNA from the viruses and then comparing the bands shown in the agrose gels they had run PCR-assays with (see Figure 4.1).²⁵⁰ The lab's research

²⁴⁸ Ronald P. Hedrick, Oren Gilad, Susan C. Yun, Terry S. McDowell, Thomas Waltzek, Gary O. Kelly, Mark A. Adkison, "Initial Isolation and Characterization of a Herpes-like Virus (KHV) from Koi and Common Carp," *Bulletin of Fisheries Research Agency Supplementary 2* (2005): 1-7.

²⁴⁹ R. P. Hedrick et al., "A Herpesvirus Associated with Mass Mortality of Juvenile and Adult Koi, a Strain of Common Carp," *Journal of Aquatic Animal Health* 12, no. 1 (1 March 2000): 56.

²⁵⁰ Oren Gilad, Susan Yun, Karl B. Andree, Mark A. Adkison, Amir Zlotkin, Herve Bercovier, Avi Eldar, and Ronald P. Hedrick, "Initial Characteristics of Koi Herpesvirus and Development of a Polymerase Chain Reaction Assay to Detect the Virus in Koi, *Cyprinus Carpio* Koi," *Diseases of Aquatic Organisms* 48, no. 2 (2002): 101-108.

team concluded from this image that while other carp viruses shared similar DNA bands with KHV, the KHV-U and KHV-I are exhibited more bands that they did not share with CCV and CHV. They conclude, based on Hedrick et al's results in 2000 and this genetic difference study that "further characterization of KHV-I and KHV-U by examination of virion polypeptides and RFLP analyses of genomic DNA indicates that the agents are identical but clearly different from CHV and CCV."²⁵¹ With this examination of the DNA of isolates from USA and Israel, the lab group deduce that "since both geographically distant isolates appear to be identical, this argues for a common origin of the virus together with a rapid spread from that source."²⁵² They rebutted the idea that KHV might be a more virulent form of CHV, writing that the PCR assay they had developed in their 2002 study argued against KHV being a variant and that

The disease caused by KHV differs in 2 key characteristics from that caused by CHV. KHV causes significant mortality among young, juvenile and adult fish, and there is no evidence of skin tumor formation in survivors of KHV infections.²⁵³

²⁵¹ Oren Gilad et al., "Initial Characteristics of Koi Herpesvirus and Development of a Polymerase Chain Reaction Assay to Detect the Virus in Koi, *Cyprinus Carpio Koi*," *Diseases of Aquatic Organisms* 48, no. 2 (2002): 106.

²⁵² Oren Gilad et al., "Initial Characteristics of Koi Herpesvirus and Development of a Polymerase Chain Reaction Assay to Detect the Virus in Koi, *Cyprinus Carpio Koi*," *Diseases of Aquatic Organisms* 48, no. 2 (2002): 106-107.

²⁵³ Oren Gilad et al., "Initial Characteristics of Koi Herpesvirus and Development of a Polymerase Chain Reaction Assay to Detect the Virus in Koi, *Cyprinus Carpio Koi*," *Diseases of Aquatic Organisms* 48, no. 2 (2002): 107.

These factors hinted to the scientists that they were dealing with a new distinct disease.

The new disease presented two problems: first scientists had to be sure that it was a distinct disease, not merely a more virulent or lethal version of other viruses, and second, that there had to be a consistent and reliable way to detect it. Hedrick et al had developed the KF-1 cell-line in an effort to isolate and detect viruses from infected koi, but could only imply based on anti-gen responses that KHV and CHV were probably not the same diseases. This was not very definitive. Oren Gilad and his colleagues later felt that using the KF-1 cell-line to detect KHV was far less effective than the PCR method Gilad et al had developed two years later in 2002. With the PCR assay, they now could more efficiently detect KHV, and using the genetic profiles they generated, could confidently state that KHV and CHV were two separate viruses. The PCR assay solved both problems at once.

Gilad and his colleagues point out further that KHV could be identified from dying fish, but not from fish that had survived KHV, and can only assume that they are carriers, since "since co-habitation with previously unexposed fish has been the principal means for spread of the virus", and their "development of a PCR assay was viewed as one method to overcome these diagnostic problems."²⁵⁴

²⁵⁴ Oren Gilad et al., "Initial Characteristics of Koi Herpesvirus and Development of a Polymerase Chain Reaction Assay to Detect the Virus in Koi, *Cyprinus Carpio Koi*," *Diseases of Aquatic Organisms* 48, no. 2 (2002): 107.

Oren Gilad at Henrick's lab had established the PCR assay as one of the main tools for characterisation of KHV, and it became the definitive diagnostic tool for identification of the presence of KHV, which many other countries used. In 2002, Indonesian authorities noted mass mortality in Blitar, East Java of koi, and had occurred after koi had been imported from China via Hong Kong. Subsequently, there had been three further outbreaks of similar mass mortality amongst common carp and koi farms in the West Java region from 2002 to early 2003.²⁵⁵ Agus Sunarto from the Fish Health Laboratory of Indonesia and colleagues developed a strategy for detecting KHV based on a diagnostic strategy developed by the Food and Agriculture Organization of the United Nations (FAO), namely environmental observation of potential KHV cases as the first step, and then using molecular biology – that is, the PCR assay as developed by Gilad et al in 2002 as the final diagnostic determination. The FAO's strategy had suggested a second step of observing histopathological changes in the fish, but Sunarto and his colleagues found it difficult to implement as "histopathological changes due to KHV infection were not obviously observed in most of the diseased fish".²⁵⁶ PCR had not only removed the

²⁵⁵ Agus Sunarto, Akhmad Rukyani, and Toshiaki Itami, "Indonesian Experience on the Outbreak of Koi Herpesvirus in Koi and Carp (*Cyprinus Carpio*)," *Bulletin of Fisheries Research Agency Supplement No. 2* (2005): 15–21.

²⁵⁶ Agus Sunarto, Akhmad Rukyani, and Toshiaki Itami, "Indonesian Experience on the Outbreak of Koi Herpesvirus in Koi and Carp (*Cyprinus Carpio*)," *Bulletin of Fisheries Research Agency Supplement No. 2* (2005): 18.

virus from the living body of the koi,²⁵⁷ but transformed into a diagnostic tool of a particular health-status.

The transmission method of KHV was also important in the characterisation of the disease. In Europe, the main source of the KHV seemed to be from Germany; while there was little to link the KHV outbreaks to those in the USA and Israel, Hedrick *et al* implied that the transmission to the US might be due to koi shows that included infected German koi, since the US koi had showed signs of KHV "10–14 days after the fish had returned from a koi show".²⁵⁸ The transnational nature of the knowledge of KHV then allowed the scientific knowledge of KHV's properties and identity to be transmitted relatively easily to Japan, as it was published in a standardized, scientific form. Using the research from Gilad and his colleagues as well as the genetic samples of the KHV that Hedrick and colleagues had isolated, Japanese officers from Niigata Prefectural Inland-water Fisheries Experimental Station developed the PCR characterisation method Gilad and colleagues into an identification tool kit.²⁵⁹ The fact that Hedrick *et al* identified a potential risk of disease transmission to be the unregulated mingling of koi during a show later grew to be an important factor in changing

²⁵⁷ Paul Rabinow, *Making PCR: A Story of Biotechnology* (University of Chicago Press, 2011).

²⁵⁸ R. P. Hedrick et al., "A Herpesvirus Associated with Mass Mortality of Juvenile and Adult Koi, a Strain of Common Carp", *Journal of Aquatic Animal Health* 12, no. 1 (1 March 2000): 47.

²⁵⁹ Kazuo Yamada, Hideyuki Karakisawa, and Hiroko Watanabe, "Preventive Measures against Koi Herpesvirus Disease in Fancy Carp in Niigata Prefecture," *Bulletin of Fisheries Research Agency* 2 (2005): 73-75.

aquaculture practices and the implementation of disease management protocols at koi shows and farm practices.

4.2 Immediate response to KHV in Niigata in 2003

It did not take long for Japan to react to KHV. The virus was "designated as a 'Specific Disease' under the Law to Ensure Sustainable Aquaculture Production (LESAP)"²⁶⁰ on June 30, 2003 in Japan. KHV was first detected in Japan in October 2003 by a group of officials from Japan's Fisheries Research Agency and the Ibaraki Prefectural Freshwater Fisheries Experiment Station.²⁶¹ The virus had been found in a common carp population in Lake Kasumigaura. Soon after in early 2004, the virus caused the mass mortality of an estimated 60-80% of Lake Biwa's common carp population.²⁶² This was of great concern to Japanese scientists and industry leaders, as "the disease is a great threat not only to the cultivation industry and koi collectors"²⁶³ because "[only] carp and koi are susceptible to KHV disease with resulting high mortality, whereas other closely related species such as goldfish (*Carassius auratus*) and grass carp (*Ctenopharyngodon idella*) are not affected."²⁶⁴

²⁶⁰ Toshihiko Matsusato, "Preface", *Bulletin of Fisheries Research Agency* Supplementary 2 (2005): i

²⁶¹ Motohiko Sano, Takafumi Ito, Jun Kurita, Takanori Yanai, Naoki Watanabe, Satoshi Miwa, and Takaji Iida. "First detection of koi herpesvirus in cultured common carp *Cyprinus carpio* in Japan." *Fish Pathology* 39, no. 3 (2004): 165-167.

²⁶² Kazuaki Matsui et al., "Detection and Significance of Koi Herpesvirus (KHV) in Freshwater Environments", *Freshwater Biology* 53, no. 6 (2008): 1262.

²⁶³ Toshifumi Minamoto, Mie N. Honjo, and Zen'ichiro Kawabata, "Seasonal Distribution of Cyprinid Herpesvirus 3 in Lake Biwa, Japan," *Applied and Environmental Microbiology* 75, no. 21 (November 2009): 6900.

²⁶⁴ Kazuaki Matsui et al., "Detection and Significance of Koi Herpesvirus (KHV) in Freshwater Environments," *Freshwater Biology* 53, no. 6 (2008): 1263.

Detection of KHV was deemed vitally important, and the use of the PCR characterisation tool was quickly translated into a diagnostic tool and adapted into the detection protocols in Japan's aquaculture regulations. Japan's Ministry of Agriculture, Forestry and Fisheries (MAFF) requested that every Prefecture were to try and detect KHV, and announced that the Fisheries Research Agency (FRA) had conducted studies to establish guidelines "which provides etiological information, symptom, diagnostic procedures by a polymerase chain reaction (PCR) test for KHV detection and other important characteristics of the disease."²⁶⁵ Much of this work was reliant on the research that Dr. Hedrick and his colleagues had started, and started turning the research tool developed by Gilad into a diagnostic tool kit.

To signify the urgency Japanese fishery organizations felt about KHV, two Japanese organizations, on March 13, 2004, the Fisheries Research Agency (FRA), the Fisheries Agency Japan (FAJ), and two international organisations, the Southeast Asian Fisheries Development Center (SEAFDEC) and the World Organisation for Animal Health (OIE) collaborated to host an International Symposium on Koi herpes virus disease (KHVD) in Yokohama, Japan, to share information about status of the disease in various countries. They also shared the studies that scientific experts from the FAJ and FRA had conducted when the KHV was first characterised as a disease, and best practises to prevent

²⁶⁵ Toshihiko Matsusato, "Preface", *Bulletin of Fisheries Research Agency*, Supplementary 2 (2005): i-ii.

the disease from spreading. The symposium signified the urgency that the fishery agencies in Japan felt regarding the disease, as well as the commercial threat that KHV posed to common carp and koi industries in much of the world, particularly USA, Europe and Israel. Hedrick and his colleagues, and various other scientific collaborations had discovered the KHV was not only distinct from other herpes viruses like CHV, but also was highly specific to the species *Cyprinus carpio* – the common carp and ornamental koi. Common carp farming for food and economic reasons was huge in Europe, particularly Eastern Europe,²⁶⁶ and therefore the highly lethal and specific KHV posed significant economic threat. It was at this symposium that Hedricks et al presented a paper summarizing their previous findings in 2000, with colour photographs of the physical characteristics of KHV infected koi. They showed discoloured patches on the skin of the koi, sunken eyes, and most importantly, necrosis or tissue-death of the gills (see figure 4.2). They distinguished KHV from other carp viruses by first noting the distinct differences in infection targets and symptoms (carp pox or *Cyprinid Herpesvirus-1* (CyHV-1) only infected carp younger than two months, and the survivors of infection displayed "papillomatous-like growths", while KHV was indiscriminate of carp age in infection, and had no particular distinctive physical signs), and genetic differences (CyHV-1 or CHVD and KHV appear closely related based on genomic

²⁶⁶ Marc Y. Engelsma and Olga LM Haenen, "KHVD, Diagnosis, Control, Research and Future in the Netherlands and Europe", *Bulletin of Fisheries Research Agency* 2005, no. 2 (2005): 13-14.

DNA based on Gilad *et al.*'s PCR assays developed in 2002) as well as host-specificity (*Cyprinid herpesvirus-2* or CyHV-2) is highly infectious to goldfish, but does not infect koi or common carp – while KHV is infectious to koi and common carp but goldfish are resistant to KHV).²⁶⁷

The overview of KHV detection confidently endorsed Gilad and his colleagues' work in 2002, as well as other groups' attempts at PCR assays by stating that "PCR method has proven to be an effective means to detect viral DNA in a number of fish tissues during the acute disease and for a period following recovery."²⁶⁸ The PCR method was eventually adapted into a KHV identification tool kit for Japan. The characterisation of KHV as first a virus that only affected koi and common carp, and then an identification tool spelled the translation of scientific inquiry into simple tool that could be easily used by even those who were not specifically trained in virology, which meant that both farmers and policy makers could easily use this tool as a way to identify the presence of KHV.

4.3 The Impact of 2004 Chuetsu Earthquakes

In the midst of the intense concern KHV had been inspiring, the Chuetsu area of Niigata prefecture was hit by a series of devastating earthquakes in 2004. The first of the series measured at a magnitude of

²⁶⁷ Ronald P. Hedrick et al., "Initial Isolation and Characterization of a Herpes-like Virus (KHV) from Koi and Common Carp," Bulletin of Fisheries Research Agency Supplementary issue 2 (2005): 4.

²⁶⁸ Ronald P. Hedrick et al., "Initial Isolation and Characterization of a Herpes-like Virus (KHV) from Koi and Common Carp," Bulletin of Fisheries Research Agency Supplementary issue 2 (2005): 6-7.

6.6. Many homes collapsed, especially in Ojiya city, resulting in thirty-nine fatalities and more than a hundred thousand people fleeing and evacuating the area. The earthquakes caused much property damage as well, and of particular concern in this thesis chapter, resulted in the destruction of many koi farms as well as water-mixing and koi escaping or dying, which "caused breeders to transfer their Koi among each other"²⁶⁹ (See Figure 4.3 for an example of the damage to the koi museum housed in Ojiya city). The damage due to the earthquakes coupled with the serious threat of KHV proved to be the impetus to change farming practices in Niigata.

Previous farming set-ups before the Chuetsu earthquake in 2004 allowed water waste and rainfall overflow to drain and flow downhill to other ponds and farms. It was a particularly wide-spread practice when the farms dot all the sides of the plentiful mountainsides of Ojiya in Niigata (see figure 4.4 for a drawing representing the water flow between farms). While it had been known that waterborne diseases existed, it was considered too expensive to restructure the farms to prevent this water mixing. Even dealers who bought koi from various farms would keep all the koi of the same breed together, separating koi by 'type' or breed rather than by source-farms. Prior to the KHV outbreak, disease such as bacterial infections were detected by

²⁶⁹ "KHV Q&A", *International Nishikigoi Promotion Center* accessed October 30, 2017, http://www.japan-nishikigoi.org/khv_qa.html

observation of the koi's skin, and separation of koi was far too costly for the farmers as they had too many fish to do so.²⁷⁰ When KHV was detected in other prefectures, the head of Fish Disease and Environment Section of the Niigata Experiment Station, Dr Shoh Sato realised that such a practice was far too risky to allow to continue, and he and his colleagues pushed for koi farmers to start rebuilding to stop such a free exchange of water between the ponds and each farm. The risk of unregulated mingling amongst koi that Hedrick *et al* had written about in 2000 was now the direct cause for farming and husbandry restructuring, with the earthquake serving as an impetus to start said restructuring.

Soon after the 2004 earthquake, the Niigata Experiment Station received a restoration budget from the government to aid in restoring the koi farms and also to rebuild in such a way to prevent cross-contamination of water as the officials felt that they "couldn't let the Koi suffer infection by KHV on top of the damages they got from the quake."²⁷¹ Soon after the earthquake, koi dealers changed their own handling of koi by categorising their koi by farm source rather than koi breed type, for fear of spreading infection.²⁷² Despite the wistful acknowledgement by Dr Sato that "you could see the quality of the koi better when you saw the same types together,"²⁷³ by 2008, the major koi

²⁷⁰ Hoshino Satorou, translated by Dr Sato Shoh, in conversation with author, October 28, 2016.

²⁷¹ "International Nishikigoi Promotion Center/Koi Disease/KHV Q&A" Accessed 10 February 2017. http://www.japan-nishikigoi.org/khv_qa.html.

²⁷² Dr Sato Shoh, interviewed by author, October 28, 2016.

²⁷³ *Ibid.*

shows in Niigata and Tokyo had changed their display practices to follow the Experiment Station's suggestion to prevent water-contamination and mixing by displaying koi in tubs organised by farm rather than by koi breed type. The Experiment Station also started implementing a security measure developed in 2005,²⁷⁴ utilizing the PCR identification tool kit and a standardised protocol of quarantine to hopefully prevent KHV from spreading into Niigata. The more securitized measures of quarantine was influenced by the understanding that KHV was transmitted in the water, and the fear of having the now tangible threat of KHV invade and spread amongst koi. Additional management practices included the treating of waste-water from koi ponds and tubs with bleach before disposing of the water into drains that flowed away from any farms.

Despite the security measures to prevent KHV from spreading to Niigata, however, the koi herpes virus (KHV) was first detected in Ojiya city of Niigata prefecture in June 18, 2006,²⁷⁵ demonstrating the fluid and connectedness of the virus transmission. As Niigata Prefecture was the prefecture from which the majority of koi was cultivated and exported to the rest of the world, the detection of KHV generated much concern amongst the Niigata Inland Freshwater Fisheries Experiment Station officials and International Nishikigoi Promotion Center (INPC).

²⁷⁴ Kazuo Yamada, Hideyuki Karakisawa, and Hiroko Watanabe, "Preventive Measures against Koi Herpesvirus Disease in Fancy Carp in Niigata Prefecture," *Bulletin of Fisheries Research Agency* 2 (2005): 73-75.

²⁷⁵ "KHV Reports, Vol.1 June 28th, 2006", *International Nishikigoi Promotion Center* accessed October 30, 2017, <http://www.japan-nishikigoi.org/disease.html>

The INPC had been formed in Niigata to promote the appreciation and spread of koi globally; KHV threatened both the prefecture economy and the INPC's interests. Both associations started an investigation into locating the source of the infected koi. During the INPC and Niigata Experiment Station investigation on the KHV appearance in 2006, INPC and the Niigata Experiment Station officials had instituted a "voluntary restraint on koi distribution,"²⁷⁶ and after the final report in September 2006, lifted this restriction.

While there was hysteria about KHV spread into Niigata, the INPC was relatively open about the progress of their investigations. The INPC published reports on their website after the first incidence of KHV in 2006. These reports apologised for the certain anxiety that farmers and hobbyists would have in the wake of this new and scary disease. For example, the report from the Experiment station stated,

On June 30, 2006, representatives of Niigata Nishikigoi breeders, officials from the prefectural government and the Inland Water Fisheries Experiment Station, and fish diseases trainers appointed for each area by the Niigata District of All Japan Nishikigoi Promotion Association gathered to give a status report and to confirm countermeasures against the disease. Niigata, being the birthplace and the world's largest production area of Nishikigoi, has thorough disease control guidelines and has never, not once,

²⁷⁶ Ibid.

let the Koi become infected with the KHV disease. Unfortunately, a Koi brought in from another prefecture for spawning purposes was a KHV carrier, and KHV was detected for the first time ever from a Niigata breeder's Koi.²⁷⁷

The INPC was quick to reassure hobbyists and farmers that they made prompt countermeasures against this incident, laying out the details of how they traced the other breeders who might have had connection to this particular breeder's fish, and then culled all fish that had connection to it, including any fry, stating that they were "taking severe measurements based on the 'punish those in doubt' principle", by not waiting for test results on these particular individuals but by culling any fish and fry that might have been in any contact, just in case, a little like cutting away healthy tissue with diseased tissue. This allows "breeders which owned the KHV infected Koi have culled part of their Koi but still keep breeding many Koi that have been confirmed to be safe. They will be sold along with other breeders' Koi when their safety is completely confirmed."²⁷⁸

Traceability of infected individuals became a priority in the animal management practices of koi. The INPC and the Niigata Experiment Station tracked down the source of the infected koi to a specific farmer's koi, and "all possibly infected Koi from that source

²⁷⁷ "KHV Reports, Vol.2 July 7th, 2006", *International Nishikigoi Promotion Center* accessed October 30, 2017, <http://www.japan-nishikigoi.org/disease.html>

²⁷⁸ Ibid.

have been inspected and culled."²⁷⁹ Officials from the Inland Water Fisheries Experiment Station and the INPC were thus "in the process of reinspecting [sic] all Niigata Koi to prevent the spread of KHV". The surveillance and monitoring of the disease status developed quickly. A follow-up report a month later on July 27 reported that the INPC and the Experiment station officers made "made a list of the breeders who interchanged Koi with the breeder who owned the infected Koi. The list consisted of 8 breeders, inside and outside of Niigata. All the infected Koi were culled." They were "taking severe measurements" by culling "koi fry that had relation with the infected Koi in some way or another, even if they were free from the possibility of infection" in order to "eliminate the remotest possibility of infection."²⁸⁰

With KHV visibly affecting the koi and a looming threat to the Niigata koi industry, the INPC worked with the Niigata Experiment Station to develop ways for Niigata farmers to modify their farms to reduce the spread of KHV. One such action was for officials to advice farmers to isolate each farm pond in such a way to prevent water flowing between ponds and between farms. This advice was given in in 2003, as prior to that, water was allowed to flow freely and especially down-hill, as the koi farms were built mainly on the sides of the

²⁷⁹ "KHV Reports, Vol.1 June 28th, 2006", *International Nishikigoi Promotion Center* accessed October 30, 2017, <http://www.japan-nishikigoi.org/disease.html>

²⁸⁰ "KHV Reports, Vol.2 July 27th, 2006", *International Nishikigoi Promotion Center* accessed October 30, 2017, <http://www.japan-nishikigoi.org/disease.html>

mountains in Niigata.²⁸¹ After the 2004 Chuetsu earthquakes, this advice was implemented in the restructuring of koi farms in Niigata.

The integration of the PCR diagnostic tool into koi management practices changed the protocol in Japan. It allowed the immediate response of in Niigata to the appearance of KHV to include the tracing of the first infected and then culling of any individuals that might have had contact, with the rise of rhetoric around the KHV in Niigata was about the "eliminate" KHV and "prevent it from spreading further", and the final report from INPC in 2006 was a pleased announcement that "the KHV problem has now terminated."²⁸² These protocols subsequently had a strong impact on daily farm practices in Niigata.

4.4 KHV's impact on Niigata's aquaculture animal management

While the INPC closed the chapter of KHV in 2006, this was not the end of animal management protocol and regulation in Niigata. As I had mentioned in the beginning of the previous subsection, KHV had been detected in freshwater lakes of Japan in 2003 and 2004. In 2004, even before the 2006 detection of KHV in Niigata, the officials in the Niigata Experiment Station set up a separate wet-lab to study the pathology of the KHV. As the disease was transmitted via a water medium, great care was taken by Dr Sato in ensuring that the water-

²⁸¹ Dr Sato Shoh in conversation with author, November 2, 2016.

²⁸² "KHV Reports, Vol.5 September 1st, 2006", *International Nishikigoi Promotion Center* accessed October 30, 2017, <http://www.japan-nishikigoi.org/disease.html>

inlet and water discharge was isolated from the rest of the lab. They did this by first setting aside an area of the Niigata Experiment Station in the basement downhill from the rest of the labs, with limited entrances that were only accessible past sanitizing foot baths. The water pipes that took out waste-water from this wet lab was not combined with the rest of the other labs, and was treated with bleach before being discharged into the storm drains. The lab officials worked concurrently with other scientists to try to characterise the virus' life-cycle and transmission modes in order to develop techniques and regulations to prevent the lethal infection of koi – which in turn would have devastating consequences for the Niigata economy. In 2005, officials from this research group devised a protocol for preventive measures against KHV.²⁸³

Control and management of KHV became part of the Niigata Experiment Station's officers' duties, especially after September 2006 export of koi was once again allowed. International customers had sent "messages of understanding and encouragement" to the INPC "regarding the KHV infection research results"²⁸⁴ and "have expressed concerns on why the real names of the breeders or Koi Farms who owned the infected Koi have not been disclosed,"²⁸⁵ showing that the

²⁸³ Kazuo Yamada, Hideyuki Karakisawa, and Hiroko Watanabe, "Preventive Measures against Koi Herpesvirus Disease in Fancy Carp in Niigata Prefecture," *Bulletin of Fisheries Research Agency* 2 (2005): 73-75.

²⁸⁴ "KHV Reports, Vol.5 September 1st, 2006", *International Nishikigoi Promotion Center* accessed October 30, 2017, <http://www.japan-nishikigoi.org/disease.html>.

²⁸⁵ *Ibid.*

disease-free status of Niigata's koi was a critical concern of buyers, especially international buyers.

In June 2006, officials released a statement stating that they had discovered a koi with early stage KHV, but "because the Niigata prefectural government and breeders have always secured a crisis-management system, there is little need to worry about the spread of the KHV disease." Part of the action to remove this threat of disease by culling all possibly infected koi and inspecting koi in Niigata. From June to September 2006, the Niigata Experiment Station kept the public updated with reports on their efforts to control the spread of the disease by detecting, quarantining and culling suspected infected individual fish.

Eventually disease inspection expanded into setting up of regulations of koi inspection required for export of koi internationally.²⁸⁶ The Niigata Experiment Station instituted a strict protocol to ensure that koi leaving the country was disease free (See Figure 4.5). The diseases specifically tested for were Spring Viraemia of Carp (SVC) and KHV. Farmers who wished to export koi internationally had to apply for an export license. One of the main requirements to qualify for this license included the farmer having his fish test negative for both diseases for two consecutive years (See Figure 4.5). If disease, particularly KHV, were to be detected in the pond amongst any of the

²⁸⁶ Dr Sato Shoh, interview with author, November 2, 2016.

individuals, all of the koi in that pond would be culled. Dr Sato presented these requirements in Singapore 2015 during the Asian Koi Show to reassure Singaporean buyers of the stringent measures that Niigata Experiment Station Officers had implemented to guarantee KHV-free koi from Niigata.

The main method that the Niigata Experiment Station still used to test for the presence of KHV was developed in 2005.²⁸⁷ Young "valueless"²⁸⁸ koi were kept with the adult koi for three weeks before samples of gill, kidney and heart tissue were taken to test for the presence of KHV. The main objective of the development of this test was to "prevent the entry of the KHV into the prefecture and to prevent the spread of the virus within and out of the prefecture, both domestic and abroad, if the virus is detected in carp in Niigata." When KHV was detected in Niigata a year later in 2006, the detection test was available.

With the KHV detection test, the Niigata Experiment Station initiated and implemented a strict system of issuing health certificates for the koi before they could be exported. The health certificates were to certify that the koi were healthy and did not have KHV, and the koi farms were inspected twice a year. The health certificates were made necessary for farmers who wanted to export koi internationally – they were not necessary for farmers who bred koi but only sold or exchanged

²⁸⁷ Kazuo Yamada, Hideyuki Karakisawa, and Hiroko Watanabe, "Preventive Measures against Koi Herpesvirus Disease in Fancy Carp in Niigata Prefecture," *Bulletin of Fisheries Research Agency* 2 (2005): 73-75.

²⁸⁸ According to Yamada et al, young sexually immature koi were considered to be valueless, and therefore could serve as sentinel koi or sacrificial samples.

them domestically. The Niigata Experiment Station then submitted the list of approved Farmers as well as health certificates to the MAFF. While the MAFF was the body that maintained the list, the Niigata Experiment Station was the main governing body that developed and implemented the regulations for the issuing of health certificates of koi.

The regulations that Niigata officials developed continued to be used till the present. They were also adapted to accommodate importing requirements of international buyers. As of 2016, hundreds of koi were inspected before they can be exported annually in early spring.²⁸⁹ Many countries such as the US and countries in the EU had different importing regulations, up to and including the time limit that the inspections must be done in before the koi are exported just after the spring harvest of koi. For example, koi must be inspected and certified to be disease free seven days before shipment to the US. Due to the huge volume of inspections that have to take place over a short period of time, the Niigata Experiment Station outsourced their inspections to authorised private companies, freeing up their five-man division to work on refining the PCR test for KHV.²⁹⁰ The system for the issuance for health certificates was summarized by Dr Sato in Figure 4.4; the Station officers' were in charge of receiving reports from appointed veterinarians, approved inspection agencies and the issuance of the health certificates, and the final report and approval of the farmer

²⁸⁹ Dr Sato Shoh, interview with author, November 2, 2016.

²⁹⁰ Ibid.

inclusion on the export list in the MAFF.

Regulations for exporting of koi was incorporated into the normal practices of Japanese farmers. The regulations devised by the Niigata Experiment Station was stated thusly: "any fish that is shipped from another breeder will have to be isolated from other fish in a low temperature water tank for three weeks during which time the breeder will check to see whether or not the fish is infected with the virus", and that the breeder should "avoid using river water" in their fish ponds and to also "sanitize all equipment that comes in contact with fish water or the fish themselves, including staff's boots and gloves."²⁹¹ These became normal daily practice on the Japanese koi farm in order to maintain their export licensing. The translation of knowledge about KHV into aquaculture practice was developed by Niigata officials working with the farmers, and this translation was integrated relatively easily into Japanese aquaculture practice.

4.5 Implementation of regulations by Niigata officials

With health certificates becoming the koi's passport to leaving Japan, and the KHV detection test being a necessary hurdle to pass in order to get that health certificate, KHV was made visible separately from the fish, turning KHV into a separate entity that could be divided from the fish. This separate entity, however, in Niigata was so

²⁹¹ Kazuo Yamada, Hideyuki Karakisawa, and Hiroko Watanabe, "Preventive Measures against Koi Herpesvirus Disease in Fancy Carp in Niigata Prefecture", *Bulletin of Fisheries Research Agency* 2 (2005): 75.

important, with such harsh consequences if found, that positive results warranted a second look. In the event of KHV being detected in a koi shipment meant for export, the Niigata Experiment Station would order a second testing, and only after a second positive test result would order that pond's koi culled (see Figure 4.6). A farmer typically owned more than one pond in order to breed and culture his koi, and the loss of one pond for the next two years is not devastating.²⁹² In a personal interview on November 2nd, 2016, Dr Sato had said that "We want to help the local farmers," and this secondary testing and only culling of the infected koi's pond was meant to allow the farmers to continue providing for themselves economically. This highlighted how seriously KHV presence was taken by the government officials, but also showed how high in priority the Niigata Farmers' livelihoods were to officials.

The Station and the Prefecture government prioritized the Niigata farmers' economic activities, based on the multiple tests and procedure that the Station officials had formalised in 2005. They also made exporting koi a priority in the wake of the KHV in 2006, by lifting the restriction on selling koi as soon as possible after their investigation. Both INPC and the Station officers also refused to publicise the names of the farmers whose koi had been infected with KHV, saying, "Not all Koi lovers and dealers are fully aware of these procedures and KHV countermeasures" and might be "misinformed and may suspect Koi

²⁹² Dr Shoh Sato, interview with author, November 2nd, 2016.

from those breeders that are proven to be safe."²⁹³ In addition, as koi farms are run as family businesses, the farms are usually named after the family name and many farms might share the same name. By naming farmers with infected koi, "there is a great possibility that cognominal breeders or Koi farms may be mistaken for the breeder of the KHV Koi", and hence they refuse to name these farmers "to avoid the risk of involving unrelated breeders."²⁹⁴ By protecting the names of the farmers, and subsequently double-checking that the farmers' koi were really infected, and by minimising what needs to be culled, the Niigata Experiment Station very clearly prioritizes the farmers' continued economic wellbeing while allowing KHV to be visible.

Following the MAFF's request to prioritize the disease and in the wake of KHV's detection in Niigata, the Niigata Experiment Station prioritized the study of KHV's pathology in the station, and signified this with the presence of the carefully cordoned off equipment in the wet-lab meant specifically for the study of the disease. Besides the act of research in the station, the officials also put out disinfectant mats, and had been used since 2006, and was meant to be a visual reassurance to the koi farmers who visit the station for various reasons that the officials were taking the disease seriously and that they were helping to prevent the transmission. This act of placing disinfectant mats also showed up in

²⁹³ "KHV Reports, Vol.5 September 1st, 2006", *International Nishikigoi Promotion Center* accessed October 30, 2017, <http://www.japan-nishikigoi.org/disease.html>

²⁹⁴ *Ibid.*

the Niigata Prefecture Koi Show in November 2016, and all visitors were careful to rub the soles of their shoes in the wet disinfectant mat. The Niigata Experiment Station used these mats as an example of biosecurity practices that farmers were recommended to follow, and farmers such as Oomo Fujimo (who owns a large farm Nishikigoi Niigata Direct Ltd (NND)) followed suit by having disinfectant mats at the entrance to their sheltered pond facilities, and they encouraged their staff to follow disinfectant rules in the carrying out of their farming duties. In this, the koi farmers in Niigata and the state officials were in agreement – farmers followed these regulations without complaint and appeared trusting that state officials were implementing reasonable regulations.

If a koi was reported to have KHV during one of the inspections or unusual koi mortality occurs in the farm, the Niigata Experiment Station would have the koi from that pond re-inspected (See Figure 4.6 for a summary diagram of the process). Inspection and re-inspection meant having a sample or sacrificial koi that lived in the same pond taken and tissue samples taken to run a PCR assay on them. While the Niigata Experiment station had the facilities to run the PCR assay themselves, the numbers requiring testing was overwhelming, and this diagnostic test was instead carried out by consulting firms.²⁹⁵

²⁹⁵ Dr Shoh Sato, in conversation with author, November 1, 2016.

If that pond were to test positive again for KHV, then the Niigata Experiment Station officers would cull the koi and disinfect the pond, and also test other ponds on the farmer's premises for KHV. The double-checking indicated caution in the implementation of their disease management protocol, where the officials preferred to have concrete confirmation of the KHV's presence before ordering the execution of an entire pond's stock. The seriousness with which officials took the potential presence of KHV and its repercussions on the farmers' reputation and economic viability probably aided in the trust that the farmers had in the same regulations to protect the farmers and koi industry in Niigata.

4.5.1 Government focus: where does the koi industry stand in priorities?

In 2003, the MAFF had declared KHV to be an emergency that all prefectures had to deal with in their freshwater fisheries. KHV was not only a threat to koi health and life but also to the koi aquaculture industry of Niigata. The positioning meant the koi aquaculture industry was in particular need of protection. However, Dr Sato said that their actions were in an effort to support the koi farmers, "so they could continue to support themselves."²⁹⁶ The economic importance of the farmers' continuing business was also a priority to the prefecture officials. While the koi aquaculture industry in Niigata is not about rearing food and therefore is not directly about food security, koi

²⁹⁶ Dr Shoh Sato, in conversation with author, November 1, 2016.

aquaculture in Niigata is related to the prefecture's productivity and economy which requires "government support for domestic producers to ensure some measure of self-sufficiency."²⁹⁷ Animal management protocol against KHV in Niigata were thus implemented with an eye on the goal of protecting koi farmers' ability to continue rearing and selling koi. KHV was a threat to the koi farmers' livelihood, and the implementation of this protocol had to take this threat into account. The way INPC and Niigata Experiment Station reported on the management of the disease to the international public showed deliberate choices to protect farmers and their livelihoods, such as by not reporting the names of the koi farmers' whose fish had been infected.

Due to the protective measures that the INPC and the Niigata Experiment Station put in place during their investigation of the KHV infection incident in 2006,²⁹⁸ the Niigata koi farmers were able to continue selling their koi to the international market without fear of their farms or koi being avoided. Farmers with similar names did not have to worry about being implicated in having infected koi. The health certification system that the Niigata Experiment Station had implemented specified caution to prevent false-positives that could impact a koi farmer's normal operations. Koi farmers or breeders in Niigata who did not wish to export outside of Japan also did not need to

²⁹⁷ Kate Barclay and Charlotte Epstein, "Securing Fish for the Nation: Food Security and Governmentality in Japan," *Asian Studies Review* 37, no. 2 (June 2013): 227.

²⁹⁸ "KHV Reports, Vol.3 July 10th, 2006", *International Nishikigoi Promotion Center* accessed October 30, 2017, <http://www.japan-nishikigoi.org/disease.html>

apply for health certification, reducing cost and hassle to the farmers.

As a result, the way Niigata Experiment Station officers had developed a protocol involving the PCR as a diagnostic tool, but also included multiple testing to prevent false-positive tests. This allowed koi farmers to continue breeding and selling their koi without apparent detriment. In fact, koi farmers were allowed to report the appearance of unusual disease or mortality on their own volition to the Niigata Experiment Station.

In response to the protective manner that the officials were behaving towards koi farmers, the koi farmers also demonstrated their trust in the officials. They frequently sought the Station officers for advice in fulfilling the health certification requirements.²⁹⁹ The Niigata Experiment Station also had breeding experiments that koi farmers helped with by volunteering to rear the experimental breed of koi to market-size³⁰⁰ (See figures 4.8 and 4.9 for examples of the koi that the Niigata Experiment Station was breeding). The farmers' help in breeding experiments showed that the koi farmers were not only not hindered in their continuing of their farming activities, they actively sought out the expertise of Niigata Experiment Station staff. The Niigata Experiment Station staff were also able to prevail on farmers' expertise

²⁹⁹ In this incident, the koi had been bought by a buyer in Tokyo, but had left the fish with the Niigata farmer. As the fish now officially did not belong to the Niigata farmer, the testing and health certification did not fall under Niigata Experiment Station's purview. However, Dr Sato helped the farmer take some gill samples and sent them on his behalf to an accredited testing company to help fulfil the certification requirement.

³⁰⁰ Dr Sato Shoh, conversation with author, November 1, 2016. Dr Sato also showed me examples of one of the koi

in koi rearing to help develop breeds of koi. In Niigata's case, it appeared that while the farmers might not understand the scientific underpinnings of KHV's pathology, but they trusted that the Niigata Experiment officials understood and would implement fair regulations that would protect their livelihoods and thus the biosecurity regulations were considered reasonable.

4.6 Impact of KHV infection in Koi industry in Japan

Despite the incidence of KHV infection in 2006, international demand for Japanese koi had not decreased, as indicated by Singaporean hobbyists' still current desire and appreciation for Japanese bred koi, and the lack of decrease in the value of Japan's ornamental fish export. The implementation of restrictions on the export of koi had not had a detrimental effect on the koi aquaculture industry in Niigata. Despite the somewhat rosy imagery of Niigata that koi manuals might imply about the pristine environment that koi live in, KHV was and is in fact very present in Niigata. Niigata Experiment station officials still give regular talks about the current state of regulation and certification of koi health in Niigata. The certificates issued in Niigata annually still number in the hundreds. In spite of this disease and the new kinds of behaviours expected of the farmers in Niigata to curb the disease spread, koi farmers did not have unsullied reputation, but that they had made some lasting efforts. Much like in the case of the silkworm and disease, Lisa Onaga found that the analysis of the relationship between

disease specific to silkworms and the attempt to prevent it "destabilizes assumptions about Japan's indigeneity as an isolated, pure, and therefore hygienic island nation."³⁰¹ KHV was present in Niigata, but the farmers made the prevention and working around the disease part of their mundane practice. The management of disease became part of their work of farming. It was partly because these farmers are building on experiences on histories of good communication with each other, the high level of education of their practices from regulatory officials and support of their associations such as the INPC.

At present, the majority of koi bred in Niigata is sold internationally. About ninety-five percent of a koi farmer's koi could be sold to dealers, and subsequently roughly eighty percent of those are sold internationally.³⁰² In order to support his family, a farmer would find that the most profitable selling structure was to sell internationally. As I had outlined earlier in the chapter, after the KHV incident in 2006, farmers who wished to sell internationally had to obtain a health certification of two consecutive disease-free years, before they could be listed as approved for international exports.

International buyers such as Singaporean hobbyists consider Japanese-bred koi are considered to be superior to koi from other countries. For example, Singaporean farmers would import koi from

³⁰¹ Onaga, "Bombyx and Bugs in Meiji Japan: Toward a Multispecies History?"

³⁰² Hosukai, interview with author, October 30, 2016.

Japan and use them as brood stock, as the "purpose of using Japanese stock as parent brooders, is to get as close as the Japanese standard."³⁰³ Therefore despite the incidence of KHV in 2006, and ongoing KHV incidents (for example in 2007³⁰⁴ and 2008³⁰⁵), koi from Japan are still very desirable. Further evidence of the robustness of the koi export industry can be discerned from the increasing trend in value of the ornamental fish industry from Japan, despite the incident of KHV in 2003/2004, and in Niigata specifically in 2006 (See Figure 4.7). By contrast, Singapore's ornamental fish industry's export value dropped dramatically soon after the incidence of KHV in 2006. There is no similar dip in Japan's ornamental fish industry's export value. The reputation of Japanese koi's quality and health was not affected by the public appearance of KHV in Niigata. Instead, the management of the koi in accordance to the new biosecurity rules and environmental changes bolstered international confidence in the Japanese koi's robustness.

4.7 Conclusion: Translating Disease to Management Protocol

A strange new disease resulted in mass mortality, and was eventually identified and named as KHV. Experimentation on KHV was geared initially to identifying and characterising it. The use of models of other carp herpes viruses by Hedrick and his fellow scientists in the

³⁰³ Jerome Ng, conversation with author, March 25, 2016.

³⁰⁴ "Urgent Notice and Report on Infection of KHV (Koi Herpes Virus): February 19, 2007", *International Nishikigoi Promotion Center* accessed October 30, 2017, <http://www.japan-nishikigoi.org/disease.html>

³⁰⁵ "Urgent Notice and Report on Infection of KHV (Koi Herpes Virus): June 11, 2008", *International Nishikigoi Promotion Center* accessed November 5, 2017, <http://www.japan-nishikigoi.org/disease.html>

early 2000s quickly led to making the disease intelligible, and they were able to develop genetic profiles of KHV and compare them to other viruses. This development of genetic profiles was allowed the use of PCR as a diagnostic tool helped to stabilise the science of KHV, particularly in Japan, turning PCR into a technique rather than an experimentation device. The ambiguous symptoms that common carp and koi exhibited when infected became less a diagnostic tool as might be traditional in fish aquaculture, but instead a positive result from a PCR test was taken as an indicator of disease presence. However, the presence of KHV's DNA alone did not result in the diagnosis of the disease. KHV-positive water did not indicate an active presence of the virus.³⁰⁶ Only when active KHV DNA was found in fish samples did the test result warrant action from the Niigata Prefecture officials. This showed that the virus had permeated the environment to the point that only the interaction between fish and virus was a true positive result. Humans attempting to intervene and prevent KHV from infecting its host, resulted in other environmental changes that humans make around the fish affect the ability of the virus to infect the host.

PCR was a tool that helped make KHV intelligible, first by characterization, then by being able to detect it. This enabled the Japanese state to intervene in koi disease management practices. The

³⁰⁶ Toshifumi Minamoto, Mie N. Honjo, and Zen'ichiro Kawabata, "Seasonal Distribution of Cyprinid Herpesvirus 3 in Lake Biwa, Japan," *Applied and Environmental Microbiology* 75, no. 21 (2009): 6900–6904.

development of PCR as a tool allowed the translation of scientific knowledge about biological characteristics and KHV's relationship with koi into a protocol for managing koi diseases. The successful implementation of the disease protocol in Niigata meant that Niigata's protocol could act as a model for adaptation by other countries, specifically Singapore. The detection of KHV with the PCR diagnostic tool also resulted in a strong association of KHV with water. Despite the presence of KHV in water not being indicative of KHV infection of koi, water koi was in was still treated as needing to be sanitized before being released into the environment. This, in particular, was the start of a departure from scientific-based understanding of the biological properties of KHV.

The successful protocol of disease management and association of water with disease and thus now KHV meant that they were ideal systems of knowledge to be translocated and adapted into the Singaporean context for the management of KHV on Singaporean farms by Singapore officials. While the protocol seemed to be successfully implemented in Japan without a negative impact on the koi industry in Niigata, implementation of a KHV-management protocol in Singapore apparently led to a decline. In Chapter 5, I will elaborate on the adaptation of these systems into the Singaporean system, and the departure from scientifically sound disease management practice in Singapore's koi aquaculture.

Chapter 5: Disease on the Singapore Koi Farm (2006 to present)

Along the old winding road of Jalan Lekar in Choa Chu Kang, the north-western side of Singapore, sprawls the Nippon Koi Farm. Nestled against the frame of the main entrance of the walkways to the koi ponds of Nippon Koi farm, the farm owner Pay Bok Seng had placed a plastic tub with a dry spongy mat inside it, just to the side of the entrance.

While not blocking the entrance, a visitor would not be able to help but see it when walking into the farm. These tubs were placed at every walkway entrance of the farm, not just at the main entrance (See figure 4.1). While currently dry, right above the tub someone had pasted a little paper sign, faded from sunlight and time, exhorting visitors to step into the tub before entering the farm. The mat inside the tub had clearly been hand-cut to fit the tub and it was empty and dry. On the farm, where everything had a clear function in maintaining the running of the farm or were put aside temporarily, this tub seemed out of place. While I could not recall seeing tubs like this in farms and aquaria that I had visited years ago, it possessed a certain familiarity, and a few minutes thought had me realise that the function of this tub was to act as a disinfectant reservoir. The mat was meant to sit in a layer of disinfectant liquid and bathe the bottom of one's shoe when one stepped into it. Its small size and ad-hoc nature had been misleading. I recalled where I had seen a similar object. The last time I had seen such disinfectant mats

and shoe-baths had been in 2003, thirteen years ago during the height of the SARS epidemic, when these mats were meant to disinfect the soles of shoes and prevent viruses from spreading into or out of the building. Larger versions of these mats made specifically for medical purposes had appeared as if by magical mandate outside every medical facility such as polyclinics and hospitals. The tubs that were in the Nippon Koi Farm were meant to act as a barrier against a virus – the Koi Herpes Virus.

In December 2006, the Agri-food and Veterinary Authority of Singapore, known as the AVA, ran a full page spread on the Koi Herpes Virus in their industrial bulletin, *AVA Visions* (See figure 4.2). The bulletin, targeted mainly at people involved in the agricultural, pet and food industries of Singapore, informed koi owners and dealers about the steps that the AVA had taken to prevent the disease from entering Singapore, using "quarantine measures" to "control[s] KHV."³⁰⁷ The information in the bulletin about the disease and the measures the AVA was using to control its spread brought to mind the concept of the virus being a specific, separate entity that infected koi but also as an entity that could be controlled, monitored through farmers' being "vigilant" and by sending koi samples³⁰⁸ to the AVA to be tested. This particular choice of term rendered the koi fish from a whole animal to that of a

³⁰⁷ Agri-food and Veterinary Authority of Singapore (AVA), "Keeping Koi Herpesvirus (KHV) at bay," in *AVA Vision*, December 2006, 11.

³⁰⁸ Agri-food and Veterinary Authority of Singapore (AVA), "Keeping Koi Herpesvirus (KHV) at bay," 12.

'sample', its status of being sacrificed for the screening for the virus transforming it from a whole animal to that of being a 'sample', not a fish. The disease became elevated to the cause of "disasters that have occurred in other countries,"³⁰⁹ disasters that could be prevented by local farmers, but also by a governmental agency, if they were vigilant, which in turn prioritized the disease into a national security issue. The disease, as I had outlined in the previous chapter, had already been known and considered, especially in Japan, as a high priority disease that could affect koi and common carp aquaculture industries.

The KHV incident in Singapore was not the first animal disease to become a national security issue in Singapore, and certainly would not be the last. Previous bulletins hint at the various actions that the AVA had been responsible for in managing zoonotic diseases such as mad cow disease, and avian flu in the South-East region in 2003. As AVA's focus regarding those cases were mainly in securing safe food supplies for the population and thus strengthening 'food safety' as a concept in Singapore. This concept of food safety was quickly associated with that of biosecurity. The term "biosecurity" kept cropping in conjunction with food safety in various government bulletins.³¹⁰ In November 2003, AVA proudly announced their food security and biosecurity measures were received positively by the International

³⁰⁹ "Keeping Koi Herpesvirus (KHV) at bay," 12.

³¹⁰ Publications of *AVA Visions* in 2003 to 2006 kept mentioning biosecurity in conjunction with food safety.

Advisory Committee of Exports (IAC) a committee that the AVA had appointed to investigate biosecurity regulations comprising of various international heads of agricultural departments. The head of the committee, Dr Gardner Murray, the Australian Chief Veterinary Officer and Executive Director of Product integrity, Animal and Plant Health, at the Department of Agriculture, Fishery and Forestry, Australia, was quoted as saying, "biological risk is never static,"³¹¹ and that the AVA should not become complacent in its food safety programmes. This strongly linking food safety to biological risk, a huge aspect of the concept of biosecurity. Since zoonotic diseases affect humans via animal hosts or intermediaries, animal disease is unsurprisingly linked to biosecurity. Since animal disease appears more frequently amongst animals with high population densities, a situation which occurs on animal farms, actions in the name of biosecurity consequently exert strong pressure on the running of animal farms. The same pressure exerted from food safety would be turned onto ornamental fish, koi in particular.

Singapore's animal farms raising food animals meant for human consumption were strongly affected by actions enacted with the rhetoric of biosecurity. When the source of something that was necessary in for life is threatened, the human population is exposed as vulnerable to risk. In this case, biological risk. Enacting biosecurity was in effect the way to

³¹¹ "Food safety and biosecurity gets the thumbs-up from experts," in *AVA Vision*, November 2003, 2.

mitigate biological vulnerability. In 2003, the avian flu in the South-East Asian region prompted a conflation of the concepts of food security and biosecurity. In the name of biosecurity, the AVA started to enact and enforce certain policies to curb the spread of avian flu and protect the food source of Singapore's population. These policies appear to form a framework that allowed similarly strong application to other kinds of animal diseases. Thus when the Koi Herpes virus (KHV) became an issue in 2006, regulations in the biosecurity umbrella quickly became extended and enforced on the koi industry, an ornamental fish industry that had very little to do with food security. Much of this was in learning from the Japanese animal management protocols, folding these into the already existing framework of animal management in Singapore termed "biosecurity." From the government perspective, farming is viewed as a profit generation industry. And actions of biosecurity enacted is to protect this revenue stream or what is viewed as factors that enhance this revenue stream. The narrative of vulnerability meant that the biosecurity regulations were effective in reducing vulnerability, whether it was in terms of food security, human health, or economic.

Singapore's ornamental fish industry had been touted since 1989³¹² as being an important primary industry of Singapore, and by

³¹² A. A. Fernando and Lim S. J, "Status of Ornamental Fish Trade and Industry in Singapore," in Aquarama Proceedings, First International Aquarium Fish and Accessories Conference, (1989), 7.

1997, was considered a world class industry in fish quality.³¹³ In the face of the 2006 KHV epidemic, the term "KHV-free" was used to indicate the world class quality of the Singapore groomed and cultured koi. Singapore koi being disease free, and at this point of time, KHV-free was a reflection of not just the ornamental fish industry but also important for Singapore's reputation as an exporter of world class and desirable goods. The behaviour of biosecurity enactment in Singapore therefore is partially driven by the attempt to protect this branding.

The language of biosecurity was not a promise of security and safety,³¹⁴ but instead played into Singapore's post-colonial narrative of precarity, drawing out fears of potential disaster by playing on the narrative of constant vulnerability. This thread of constant vulnerability, constant precarity, had continuously run through the ornamental fish industry, even right from the very beginning. In an article about better packing methods, then-Head of the Freshwater Aquatics division of the Primary Production Department of Singapore (pre-cursor to the AVA) had written that Singaporean farmers needed to "maintain a competitive edge over their counterparts in other countries" by "[enhancing] the quality of the fish through eradication of parasites,"³¹⁵ an ever present reminder for Singapore not to rest on their laurels and to constantly

³¹³ Ling Kai Huat and Lim K. C., "Quality Enhancement of Ornamental fish prior to Export," Paper presented at the Aquarama '97 the 5th International Aquarium Fish and Accessories Exhibition and Conference, Singapore, 1997.

³¹⁴ Caduff, "Visions of Biological Vulnerability," pp. 115

³¹⁵ Ling K. H., Lim L. C. and Cheong L., "Quality Enhancement of guppies for export: Eradication of parasites," *Singapore Journal of Primary Industries* 24 (1996), 46.

strive for improvement, for fear of other nations catching up. In the rest of this chapter, I shall highlight the constant running thread of how the Singapore state existed with a vulnerability narrative, and utilized it around the ornamental fish industry, particularly when KHV was first announced in Singapore.

By studying the events around the KHV and its subsequent biosecurity issues with a framework of Foucault's governmentality and the application of biopower³¹⁶ on the koi industry by the Agri-food and Veterinary Authority (AVA) of Singapore, the translocation of koi disease management protocols from Japan and how they were adapted to the Singapore environment is made clearer in this chapter. I intend to show how Japan's regulatory protocols was adapted and translated within the Singapore's existing framework of disease management and visualisation. This analysis also will show the impact these regulations had on the koi industry and ornamental fish industry of Singapore, as well as illustrate the factors leading to the decline in the ornamental fish industry in Singapore. In this analysis, the envisioning of disease is important to understanding the particular framing of biosecurity regulations that the AVA used to intervene in the koi industry, and the consequences for farmers and hobbyists as a result of this framing. In this chapter I shall elaborate on the history of biosecurity and the consequent envisioning of human disease. In particular, I shall trace

³¹⁶ Michel Foucault, *Discipline and Punishment* (London: Allen Lane, 1977). Particularly the chapter "Docile Bodies", 135-169.

how biosecurity emerged and influenced the rhetoric, treatment and strategies utilized by the government of Singapore in dealing with non-human disease. Consequently, in order to deal with KHV in Singapore, AVA officials translated the koi disease management protocol developed in Japan (as detailed in Chapter 4) to fit under the biosecurity framework for animal-for-consumption management (e.g. swine and chickens). Then I shall analyse the resultant tension from the exercise of governmental regulations on the day-to-day running of koi farmers, and the reaction from koi farmers due to their vernacular understanding of disease. I shall conclude with how the translation of knowledge into aquaculture practice in Singapore had an unexpectedly detrimental consequence on the ornamental fish industry as a result of differing motivations from the AVA versus that of other human actors in Singapore's koi aquaculture.

5.1 The rhetoric of biosecurity in disease-management

To start with, the government in dealing with KHV was exercising biopolitics. Biopolitics is a form of government power that addresses the species bodies of the population and therefore supplements the corporeal disciplines of anatomo-politics, although the two are inextricably conjoined in that each requires the other.³¹⁷

According to Foucault, starting in the eighteenth century, that human

³¹⁷ Majia Holmer Nadesan, *Governmentality, Biopower, and Everyday Life* (Routledge, 2010), 93.

behaviour had become under discipline and control of governing bodies³¹⁸ and with the superimposition of disease onto human body brought the human body into the field of medical knowledge and brought it into the field of power, bringing the living body under the control of the governing bodies.³¹⁹ Foucault argued that despite changing medical technologies over time, these technologies tended to deal with threats to vitality, fecundity and productivity of the population. Scholars such as behavioural scientist Majia Nadesan used this analytical framework of governmentality in the enactment of biopower to show the growth of biopolitical disciplines "that shaped the practices and value orientations of the population, including sanitary sciences, domestic hygiene, and medical hygiene."³²⁰

During the latter half of the nineteenth century, the physical environment such as the air and water was believed to be the originator of disease. Quarantine was therefore the primary mechanism used to halt disease transmission, and thus efforts on behalf of public health "focused primarily on surveillance and segregation of the ill."³²¹ This particular idea of disease transmission fit nicely with the 1990s historiographical conceptualization of disease as put forward by Martin and Crosby. An understanding of diseases in the form of pathogenic

³¹⁸ Michel Foucault, "Docile Bodies," in *Discipline and Punishment*, trans. Alan Sheridan, 2nd ed. (New York: Random House, 1977), 149-156.

³¹⁹ Michel Foucault, *The Birth of the Clinic*, trans. A. M. Sheridan, 3rd ed. (Abingdon, UK: Routledge, 2003).

³²⁰ Nadesan, *Governmentality, Biopower, and Everyday Life*, 94.

³²¹ John Duffy, *The Sanitarians: A History of American Public Health*, University of Illinois Press, 1992.

organisms grew, disease management to deal with newer understandings of disease transmission such as breath and contaminated water were added alongside to quarantine, rather than replacing it entirely.

Disease management had been envisioned as foreign bodies invading and attacking the human body,³²² which highlights the systematic nature of government and state control of bodies with the aim of achieving state objectives. The state uses militarized language to generally describe the presence of wide-spread looming disease, and is fairly common in most public health materials. Such examples include Singapore's published material "patrolling"³²³ and being "battle-fit"³²⁴ in response to diseases. This not only influenced the strategy taken by various international public health departments, it also influenced biosecurity issues.

As I had mentioned in the introduction, the positioning of disease as other and invasive externalised disease-causing pathogens but also specified other biological populations as protected and local. Once there was such a division, diseases could be cast as biological threats and as threats to security. There were vulnerable populations, and there were aggressors. The casting of disease in militarized terms was easily

³²² Emily Martin, *Flexible Bodies: Tracking Immunity in American Culture from the Days of Polio to the Age of AIDS*. Beacon Press, 1994.

³²³ Singapore, Agri-food and Veterinary Authority of Singapore (AVA), "AVA aces in fourth bird flu operational readiness test, "Exercise Gallus 4", in *AVA Vision*, December 2006, 2.

³²⁴ Singapore, Agri-food and Veterinary Authority of Singapore (AVA), "Battle-fit for birdflu", in *AVA Vision*, 2004, issue 2, 8.

integrated into the post-Cold War landscape's rubric of security.³²⁵ One concern with biosecurity is that there apparently is no inherent limiting factor.³²⁶ There can be never any stop to security, since disease constantly evolves. There would always be the vulnerable population, where when one vulnerability was protected, another new one would develop.

Singapore's position within interconnected trade-routes opened it up to vulnerability, but also to increased avenues of information transmission. The interconnected nodules of various cities and transmission threads over large spatial distances, allowing knowledge to travel along the same routes that organisms could. Networks are both objective realities that influence the patterns of disease distribution and powerful metaphors for interpreting the causes and significance of those problems.³²⁷ Using networks as a metaphor for conceptualising diseases allowed understanding how efficiency of networks reduced effective distance and reduced transmission obstacles.³²⁸ So while avenues of disease entry might increase, so too could Singapore acquire information more easily from other sources besides their own local human groups.

³²⁵ Ibid.

³²⁶ Stephen J. Collier, Andrew Lakoff, and Paul Rabinow, "Biosecurity: Towards an Anthropology of the Contemporary," *Anthropology Today* 20, no. 5 (2004): 5.

³²⁷ Nicholas B. King, "Networks, Disease, and the Utopian Impulse," in *Networked Disease*, ed. S. Harris Ali and Roger Keil (Wiley-Blackwell, 2008), 210.

³²⁸ Ibid.

Despite the tendency of the network framework to flatten constituent elements such as human vectors, or homogenize their constituent elements,³²⁹ this framework still takes into account the connectedness of today's modern city, with the cities considered as nodes of interconnected strands, rather than isolated islands of purity to be defended against. The more global perspective "brings to light the fallacy of viewing infectious diseases as being exclusively limited to specific regions of the world or to only specific social groups within a city," because diseases are "interrelated and networked".³³⁰ Conceptualising disease as part of a system is thus more nuanced than the uni-directional view of militarized disease, with Singapore unable to import the protocol from Japan and implement it wholesale and unchanged.

Instead, the Singapore's Ministry of Health continued to use the older idea of disease-as-foreign, but translated the Japanese protocol to fit within the existing framework in Singapore. The idea of disease-as-foreign came from the earlier idea of the tropics being particularly fertile for the breeding of diseases during the colonial era of Malaya,³³¹ and married to the concept that disease was from the physical environment that the target population can be removed or isolated from.³³² The

³²⁹ Ibid.

³³⁰ S. Harris Ali and Roger Keil, eds., "Part IV: Re-Emerging Infectious Disease, Urban Public Health, and Global Biosecurity," in *Networked Disease* (Wiley-Blackwell, 2008), 161.

³³¹ Lenore Manderson, "Biology, Medical Ideas and Social Context", in *Sickness and the State: Health and Illness in Colonial Malaya, 1870-1940*. Cambridge University Press, 2002, 74.

³³² Duffy, *The Sanitarians*, 49.

casting of disease into an army of foreign invaders not only utilized a familiar metaphor that security officials could understand, but allowed a militarized strategy for the dealing with biological security threats. Singapore's Ministry of Health utilized these militarized terms in talking about human diseases, particularly those that have been cast as having non-local origins, such as the Avian Flu of 2009. Strategies such as monitoring of individuals, quarantine and isolation in order to remove the foreign disease echo strategies in dealing with military threats, following in the similar vein in other histories.³³³ Treating disease as a military threat included the Singapore Ministry of Health broadcasting bulletins that called for heightened awareness, as well as increased monitoring of individuals who enter Singapore. It also in effect heightened the feeling of vulnerability in Singapore's population, for if there was something to be protected from, it meant that there was something to protect.

With the concept of disease firmly established as a militarized threat post-2003,³³⁴ all diseases, even if they did not directly impact a human population, were conceived as requiring militarized action. Hence, when KHV established itself as an epidemic threat in 2006, the biosecurity rhetoric applied to diseases in other animal systems was

³³³ Ibid.

IL: University of Illinois, 1990), 61, such as in various American cities in the eighteenth and nineteenth centuries.

³³⁴ Peggy Teo, Brenda S. A. Yeoh, and Shir Nee Ong, "Surveillance in a Globalizing City: Singapore's Battle against SARS", in *Networked Disease*, ed. S. Harris Ali and Roger Keil (Wiley-Blackwell, 2008), 100.

translated and used in the koi-system. In Singapore this translation took the shape of having very similar actions to those taken against human diseases, thus conflating animal disease with human disease.

Singapore's fear of national security being invaded by biological threats resulted in strong biosecurity regulations, which in turn was applied to KHV in Singapore. If human disease could be controlled in one manner, then so too could KHV.

5.1.1 Envisioning Disease: Implementation of Regulations

The militarized framework of disease influenced how regulations were formulated and implemented. The Avian Flu in 2003 was concurrent with SARS. When it threatened Singapore's population, certain measures in the name of managing the disease, were put in place. These were first framed in military terms³³⁵ and later named as biosecurity³³⁶ While the AVA's responsibility was focused on the avian and animal aspects of disease, the Ministry of Health focused on the human side of the disease: disinfectant shoe-baths became ubiquitous, appearing at every polyclinic and hospital entrance; heat-sensor stations were set up in Changi Airport to monitor incoming passengers for elevated temperatures; school children were issued thermometers, and expected to take their oral temperatures during morning assembly before school. These physical practices were all manifestations of the

³³⁵ Singapore, Agri-food and Veterinary Authority of Singapore (AVA), "Battle-fit for birdflu", in *AVA Vision*, 2004, issue 2, 8

³³⁶ Singapore, Agri-food and Veterinary Authority of Singapore (AVA), "Experts praise AVA's food safety and biosecurity programme," *AVA Vision*, 2005, issue 3, 3.

same ideology of biosecurity in controlling the spread of the avian flu virus that the AVA was controlling in poultry and testing for in wild-birds that passed through Singapore's borders. While the avian flu's main consequence in Singapore was a disruption of food supplies (chicken eggs, in particular, were limited), SARS had human casualties.

The use of militarized envisioning was fully utilized in the management of swine and chicken diseases thereafter. By 2004, while AVA was still conducting exercises to maintain militaristic readiness to combat the avian flu, the human side of the SARS disease management had de-escalated. MOH had published a plan titled "Preparing for a Human Influenza Pandemic in Singapore" which the Wong Kan Seng, Minister of Home Affairs during the SARS pandemic in 2003, wrote that "The outbreak of the Severe Acute Respiratory Syndrome (SARS) in Singapore in 2003 has taught us a valuable lesson on how a medical crisis could develop quickly into a national crisis",³³⁷ and the published plan was heavily influenced by the SARS pandemic and its consequences. This plan had been worked out with the AVA, and it was structured and refined after the 2003 SARS pandemic, avian flu and other animal diseases were established as potential causes for national crises. It is at this point that animal diseases were conflated with human diseases. The actions taken to protect vulnerable Singaporeans from

³³⁷ Ministry of Home Affairs, "Preparing for a Human Influenza Pandemic in Singapore" (Ministry of Home Affairs, 2014), https://www.moh.gov.sg/content/moh_web/home/diseases_and_conditions/pandemic-preparedness.html.

either was the same for both animal diseases and human diseases, with the added connection that predicted new flu epidemics would have animal origins. The developed influenza flu strategy was not only refined from the SARS pandemic and its handling, but it led to the similar measures taken to manage the KHV pandemic, even though KHV only affected carp fish, and no other ornamental fish species, let alone human health.

In the wake of KHV's appearance in Singapore in 2006, a similar measure protocol to the management of 2003's SARS showed up in the koi farms. There were disinfectant shoe-baths showed up in koi farms, and strong quarantine regulations were implemented, and the koi farmers had to comply. KHV manifests primarily as infection of internal organs such as causing dysfunction of gills, and other general signs of disease such as discolouration or fin rot, but not all fish show these symptoms. Instead, the diagnostic tool and associated protocol for managing KHV could be translocated from Japan (more details on the virus is in Chapter 4). Due to the association of the virus with koi's water, water was now linked to fish health. Fish could contract KHV by being in contact with water infected fish had been in.

The PCR diagnostic tool and associated protocol for managing KHV was not just translocated from Japan, but also translated and adapted. The AVA had taken measures and regulations initially implemented by the Ministry of Health, and modified them to include

the PCR diagnostic tool for testing for KHV presence, as well as the tests of using sentinel fish adapted from Japan's protocol. This new protocol was implemented on koi farms. The virus had little bearing on human health, and while very infectious to the fish, was understood to be transmitted by individual fish and water infected fish had been in. There was very little reason for shoe-baths on the farms to be actually effective in the management of the disease according to the koi farmers I had interviewed, other than becoming visible objects to represent the AVA's action in enacting biosecurity regulations, politicising the regulations³³⁸ and in turn the need to keep the koi safe from KHV. The action of using visible objects was associating KHV with SARS. This resulted in a tension between the farmers and the AVA, as the implementation of these new regulations upset the system that farmers already had with their suppliers and customers. The government conceptualised KHV as similar to human epidemic diseases in terms of its contagion and spread, enacting similar strategies of isolation, quarantine and tracking, requiring farmers in Singapore to enact behaviours similar to that of controlling human epidemic diseases. The koi on Singapore farms were ostensibly the vulnerable population requiring protection.

Furthermore, these regulations were encoded in ornamental fish importing regulations, specifically singling out koi and carp as being items of suspicion and note. By making "fish have not been kept in

³³⁸ Carlo Caduff, "Anticipations of Biosecurity," in *Biosecurity Interventions*, Global Health and Security in Question (Columbia University Press, 2008), 272.

water in common with koi carp or farmed food fish" a requirement for certification of good health in ornamental fish, koi have been singled out from the rest of ornamental fish, and in this particular circumstance, put on par with farmed food fish as a health-risk to ornamental fish in general. In specifying koi carp and its relatives as potentially dangerous, the AVA had isolated the koi from the rest of the ornamental fish industry, creating a strong tension between their regulations and the koi farmers. In addition, koi (and goldfish) are subject to further disease screening before they could be imported into Singapore, complicating and lengthening the duration of the process of importing koi, compared to before the KHV event, and compared to other non-carp fish such as guppies.

Farmers do not believe that the KHV is as dire as the AVA's strict biosecurity behaviour warrants.³³⁹ Total shut down of the farms from KHV detection affected the farmers' revenue and they were not pleased with having to do that when they believed that they could control the spread of the KHV within their own farm by strategic isolation of the fish themselves. The farmers were not pleased when the AVA attempted to specify that they could only practice one particular aspect of his business. One of them said, "How can the government tell me what to

³³⁹ For example, Tjo Kwe In, interviewed by author, Singapore, 25 May 2016; Jerome Ng, conversation with author, Singapore, Oct 23, 2016. Tjo said that now there are vaccines available for KHV, so koi need not be treated so strictly. Whether the existence of KHV vaccines is true, the sentiment that the state was over-reacting especially now was echoed by other farmers who had been interviewed with similar allusions.

do on my own business? Whether I breed koi only or sell koi only?"³⁴⁰ to express his unhappiness in the government attempting to dictate aspects of his business, which he felt was out of line for the AVA.

In attempting to control different aspects of koi farming at an even finer scale such as trying to make farmers choose to either to solely breed koi or act as koi hotels, the AVA was trying to enforce a particular vision of Foucaultian biopower by extending their control into individuals' businesses. Andrew Lakoff and Stephen Collier's edited volume *Biosecurity Interventions* expand Foucault's work on biopower and biopolitics,³⁴¹ and show that governmental bodies' refusal of normalization and naturalization of biological threats, evident in both AVA's and the Ministry of Health's particular language use of preventing diseases from becoming 'endemic' and 'taking root' in Singapore's biological landscape, actually problematizes the disease, and eventually defines koi as potentially pathological. In 2014, Carlo Caduff analyses this volume's thesis by saying that "this type of second-order observation provides a critical account that highlights the historical contingency of biosecurity's constructions of risk and danger,"³⁴² providing a somewhat antagonistic view of biosecurity's construction of danger in the koi industry versus that of the farmers' realities. The farmers' understanding of KHV and its perceived impact

³⁴⁰ Anonymous koi farmer, in conversation with author, October 2, 2015.

³⁴¹ Andrew Lakoff and Stephen J. Collier, *Biosecurity Interventions: Global Health & Security in Question* (Columbia University Press, 2008).

³⁴² Carlo Caduff, "On the Verge of Death: Visions of Biological Vulnerability," *Annual Review of Anthropology* 43, no. 1 (2014): 108.

on their industry and livelihood was different enough from the perception from the point of view of state officials that it became somewhat unsurprising that farmers – and later hobbyists – ascribed the decline of the industry not to the disease itself, but to the biosecurity regulations and actions of the AVA officials.

Koi in Singapore were in a unique position, being ornamental animals bred not for food. A lot of biosecurity regulation and behaviours are all about how the animal population could cause detriment to the target human population, positioning the human population as vulnerable. In Charles Mather and Amy Marshalls' examining of ostrich rearing in South Africa,³⁴³ for example, ostriches rearing practices were not as stringently regulated by 'biosecurity' because they were primarily reared for ornamental purposes. However once they were being sold as meat the animals had to meet a more stringent criteria, since they affected humans directly as being food. In a reverse case, koi as a predominantly ornamental fish, actually meets a far higher criteria than common carp. It is probably because common carp is not reared in large numbers in Singapore as a food fish for either exporting or local consumption. KHV also cannot affect the humans directly, unlike other parasites that might lurk in animal products meant for food.

In fact, as a farmer had put it, it was in order to protect

³⁴³ Charles Mather and Amy Marshall, 'Living with Disease? Biosecurity and Avian Influenza in Ostriches', *Agriculture and Human Values* 28, no. 2 (29 April 2010): 153–65.

Singapore's reputation and with the insistence from market demands of overseas after 2006 that the Singapore government enacted these regulations to maintain the reputation of disease-free export-goods embodied in the fish. The vulnerable party was not the Singapore population, nor the farmers, or even the koi themselves, but Singapore's reputation tied to disease-free ornamental fish. This political status and reputation was a vulnerable spot. The Singapore government has been politically leveraged to change their regulations before. America had once enacted an embargo in 1986 on all of Singapore's ornamental fish imports, despite the illegality of the action.³⁴⁴ While the USA had only kept this embargo on Singapore's ornamental fish imports for less than a month,³⁴⁵ the government was quickly forced to become a signatory of CITES, effectively stopping all trade of endangered aquatic species in Singapore. With the USA and Europe being Singapore's main export destinations for ornamental fish, the government's strict implementation of biosecurity to prevent the loss of KHV-free label is unsurprising. Mather and Marshall noted a policy action by the South African Department of Agri-food because of their anxiety to prove their ability to keep food safe and transparent. Singapore's AVA has similar behaviour, especially enforced by their experience of embargo by one of their biggest nation-clients. Singapore's reputation in the ornamental

³⁴⁴ Irene Ng, "US Ban on Aquarium Fish," *Straits Times* (Singapore), October 2, 1986.

³⁴⁵ Boey Kit Yin, "America warned against re-imposing fish ban", *Straits Times* (Singapore), October 15, 1986.

fish industry was vulnerable, subject to political and economic pressure.

Close examination of disease management regulations for koi show that they were not only adapted from Japan's protocols, but they were adapted to be in line with how human epidemics are treated, in terms of strategy and framing of disease as a foreign invader. According to the farmers, they have to isolate all incoming koi from the general population of local koi, track individual fish, and if discovered to be sick with KHV, have to be removed. The three main strategies are similar to normal farm practices, prior to the KHV epidemic. The reframing of these in terms of biosecurity suddenly spelled dire consequences for the farm if disease was found on their farm, much like how SARS had strong economic consequences for Singapore when the disease was found amongst the Singaporean population. Where prior to the KHV epidemic, farmers dealt with disease-outbreak on their own terms without having to report to AVA, now AVA required regular reports and certification of fish health, and in the event of a disease outbreak, farmers had to wait for AVA inspection before they were allowed to resume business. It was similar to that of the Japanese protocol of necessitating government oversight and certification, but adapted to the stricter regulations of dealing with swine and avian diseases.

SARS and avian flu not only had consequences in the reconceptualization of disease as a looming, wide-spread menace to national security, but also resulted in the positioning of health

management practices as a security issue.³⁴⁶ The government actions on koi importing claim to follow international regulations on biosecurity, practices that also influence food farming animals such as treatment of swine and avian flu. Singapore regulations are therefore highly influenced by international standards, but also the fact that in this instance of koi regulation they do not treat koi differently from food animals OR humans.

Singapore not only took the association of water with koi health from Japan, but increased control over koi's water. Koi are highly restricted compared to other kinds of fish. While ornamental, they are treated more stringently than other ornamental fish. Koi might in fact be considered a separate category from other ornamental fish altogether. Koi are subject to other disease checks, and other ornamental fish had to be declared never coming into contact with water that had housed koi.

With the AVA's course of action, threat of KHV had been securitized successfully because it had been portrayed as requiring emergency measures to be dealt with according to political scientists and security experts Buzan *et al.*³⁴⁷ and McInnes.³⁴⁸ In addition, the threat of KHV has been represented in such a way as to evoke disproportionate fear and anxiety, equating the KHV epidemic to the

³⁴⁶ Gregory D. Koblenz, "Biosecurity Reconsidered: Calibrating Biological Threats and Responses," *International Security* 34, no. 4 (17 March 2010): 96–132.

³⁴⁷ Barry Buzan, Ole Waever, and Japp de Wilde, *Security: A New Framework for Analysis* (Boulder, Colo.: Lynne Rienner, 1997), pp. 23–24.

³⁴⁸ Colin McInnes, "Health and Security Studies," in Alan Ingram, ed., *Health, Foreign Policy, and Security: Towards a Conceptual Framework for Research and Policy*, 2004, 53.

level of human health risks, further adding to the criteria of securitization.³⁴⁹ The dread of acute infectious disease outbreaks, whether natural or man-made, is crucial for these outbreaks to be successfully portrayed not just as health risks but also as security threats.³⁵⁰ With this portrayal of KHV as a security and economic risk, AVA's emergency regulations were justified, and eventually normalised into the daily running of the koi industry a decade later. Farmers and hobbyists might chafe and try to find out ways around the regulations, such as one hobbyist trying to figure out a way to import koi in his car trunk rather than declare it to border officials, but the regulations have become standard and normalised. The result of this is similar to what Caduff³⁵¹ writes in reviewing biosecurity and biological vulnerability. These actions instilled a sense that the level of risk of KHV is never nil, and instead installed a permanent sense of insecurity and create a constant state of readiness, intending to evoking a sense of constant vigilance amongst farmers regarding this disease, much like how the Ministry of Health constantly sends out bulletins on disease updates exhorting the public to be vigilant about diseases. Much as how pigs in New Zealand has been rebranded in line with the 100% Pure New Zealand's narrative in order to combat issues with animal disease,³⁵² the

³⁴⁹ Enemark, *Disease and Security*, pp. 6-15.

³⁵⁰ Koblenz, "Biosecurity Reconsidered: Calibrating Biological Threats and Responses", pp. 112

³⁵¹ Caduff, Carlo. "On the Verge of Death: Visions of Biological Vulnerability," *Annual Review of Anthropology* 43, no. 1 (2014): 105-21.

³⁵² Carr, Rachel. "100% Pure Pigs: New Zealand and the Cultivation of Pure Auckland Island Pigs for Xenotransplantation". *Animal Studies Journal* 5, no. 2 (1 January 2016): 78-100.

narrative of disease prevention is utilized in Singapore with koi.

The biosecurity framework used in dealing with koi, food animals and human disease management conflates of two different aspects of biosecurity. Koblenz (2010) laid out four different definitions of biosecurity:

1. The regulation of threats to the economy and environment posed by invasive alien organisms.
2. Prevention of microbial agents from being stolen, lost or misused, as defined by WHO, in response to bioterrorism.
3. Regulation of techniques and technologies that can be used to create pathogenic compounds or agents.
4. Defined by the National Academies of Science as "security against the inadvertent, inappropriate, or intentional malicious or malevolent use of potentially dangerous biological agents or biotechnology, including the development, production, stockpiling, or use of biological weapons as well as outbreaks of newly emergent and epidemic disease³⁵³".

In the case of human disease, AVA and the Ministry used the mind-set of dealing with bioterrorism and a health threat by giving the disease pathogen the status of an enemy agent with the use of military metaphors. The protocol for KHV management might have initially

³⁵³ Institute of Medicine and National Research Council, *Globalization, Biosecurity, and the Future of the Life Sciences*, p. 32.

been translocated from Japan, but when translated into Singapore's mindset, conflated KHV into that of bioterrorism and health threat. KHV under Koblenz' definitions should have placed it under the first definition, in that a regulation of threat to the economy as koi is not a wild-living native organism in Singapore's ecological environment. However, the similarity in regulations of koi importing and koi disease management treat koi diseases on the same level of human diseases. With the two definitions of disease conflated, it seemed like koi had fallen victim to the same issue others have pointed out in human security.³⁵⁴ As Andrew Price-Smith argued, defining all pathogens as a threat to national security, undermines the argument for biosecurity.³⁵⁵ Treating the KHV as equivalent to human disease in its management ultimately resulted in frustration among the koi farmers trying to live with and around the regulations, and a decreased confidence in the government's ability to manage the koi industry effectively.

5.2 Living with disease

When the AVA framed of KHV as a foreign invader, much of the management of the disease had to be re-framed from farm management into disease management, and it applied to both farmers and hobbyists. For example, where the isolation of new animals were common sense in order to reduce stress to both old and new stock of fish, now this act was

³⁵⁴ Roland Paris, "Human Security: Paradigm Shift or Hot Air?" *International Security*, Vol. 26, No. 2 (Fall 2001), p. 88.

³⁵⁵ Andrew T. Price-Smith, *Contagion and Chaos: Disease, Ecology, and National Security in the Era of Globalization* (Cambridge, Mass.: MIT Press, 2009), pp. 184-187

reframed as quarantine, in order to prevent introduction of the invisible disease that new stock potentially could be harbouring. While the testing of water for fish disease pathogens had been done since 1987,³⁵⁶ this also became the basis for fish health certification from the government. This act of reframing was an external directive from the government, which conflicted with the normal practice of the koi farmers. In order to continue their businesses, the farmers had to incorporate these practices and re-structure their farms to new legislation and restrictions.

With the new regulations in place, government officials also informed farmers that they were not allowed to perform certain functions on their farms. They were only allowed to act as dealers, or breeders, but not both. The farmers felt as if the government was not only out of touch with the industry but also were overstepping their bounds in telling them how to run their businesses. Tjo for example was waiting for months for AVA officials to get back to him on testing for KHV on his farm, "every month I ask them, I got overhead to run. Can I stop the pump? Cannot what! It'll kill the fish!" and the only way for him to solve his stalled farm was to no longer breed his koi, because "you breed and they come check, for what?"³⁵⁷ While he was KHV-free for three years, the bother of having AVA officials come and check on

³⁵⁶ S. J. Low, R Singh, and C. S. Tan, "Parasites and Bacterial Diseases of Imported Freshwater Ornamental Fishes," *Singapore Journal of Primary Industries* 15, no. 1 (1987): 1-11.

³⁵⁷ Tjo Kwe In, Interviewed by author, Singapore, 25 May 2016. Both Tjo and Pay mentioned similar issues with AVA's new regulations that interrupted their running of the farms.

his stock every six months was too much hassle for him to bother with.

AVA further adapted Japanese protocols in the Singapore context. The strict requirements for export certification for koi farmers and advice for farm management and consequence for disease detection is a Japanese import, but AVA's requirements for import of koi was stated as a consignment of koi with sentinel koi was "required to be quarantined in an isolated area at the importers' premises for a minimum period of 3 weeks"³⁵⁸ and if the sentinel koi were to test positive for the presence of KHV, the entire consignment was culled. AVA went further and implemented a halt to the farm's proceedings as well in the event of a KHV detection.

The farmers' acquiesce, however reluctant, meant that koi cultivation was permanently modified in Singapore. Farmers now were not attempting complete aquaculture, having to choose between breeding and exporting only, with many deciding to give up on breeding koi. This was one of the important modifications from the protocol in Japan, where health certification was only required if the koi was to be exported, not whether they were being bred.

Singapore's biosecurity regulations were targeted, ostensibly, as protecting the end-buyers from purchasing diseased koi. Singapore koi hobbyists were part of this demographic, and thus have to deal with the

³⁵⁸ Ling, Kai Huat, Susan Ling Fung Kueh, and Yew Kwang Poh, "Quarantine, Surveillance and Monitoring of Koi Herpesvirus in Singapore", *Bulletin of Fisheries Research Agency*, Supplementary vol. 2 (2005): 39.

disease. In a sense they were the apparent vulnerable party. Much of the management of koi and general health comes from observation of the animals themselves, and monitoring of the environment with simple rubrics such as water temperature, pH, nitrate and ammonia levels.

Similarly, hobbyists in Singapore deal with disease with the idea of prevention. Much like farmers rearing ostriches in Mather and Marshall's case-study realised that the environment had an influence on disease in their stock,³⁵⁹ it has been long since recognised by farmers and hobbyists alike that environmental stressors cause illnesses in fish or at least make them more susceptible to disease. Hobbyists keep the stocking density of their ponds low, and farmers watch their water-quality constantly, attributing the water quality maintenance to either good water filters or to microbial components in the aquatic environment, and monitor circumstances that affect their ponds such as rainfall. In this sense, farmers and hobbyists were and are living with the disease. They were allowing environmental factors such as rainfall to influence their actions in taking care of their fish. It meant they were working with the environment and the fish themselves. While neither the hobbyists nor farmers mentioned immune systems of their fish, the general understanding was that the health of the fish were best maintained in good environmental conditions with few stressors. Without using the PCR diagnostic tool, the apparent good health and

³⁵⁹ Mather and Marshall, "Living with Disease," 153–65.

normal behaviour of their fish was taken as being KHV free.

While Singaporean hobbyists could choose to buy koi from farms not infected with KHV, the treatment of KHV as a foreign invader had influenced the koi hobby scene nonetheless. Since the number of farmers in Singapore was so small, numbering five koi-only farmers, all the hobbyists eventually got to know the few koi farmers in Singapore and their specialities. They also got to understand and know the problems that each farmer faces. For example when Mr Bok's farm had to be shut down for several months, not only did the other farmers know about it, but so did the majority of the koi hobbyists as well. Other Singapore farmers and hobbyists had their own opinion of the occurrence, mainly disapproving of the government's action and sympathizing with Mr Bok.³⁶⁰ The majority of the farmers and hobbyists viewed the regulations as not only out of touch but as draconian, with hobbyists trying to find out ways to avoid the quarantine period of new imported koi, and bemoaning the fact that "in the past" they could bring koi home from farms instantaneously.³⁶¹ Hobbyists also bemoan the lack of new young blood into the hobby as a direct outcome of these regulations. They do agree that other factors influence the lack of people being interested in koi rearing, such as the inability for many young people to have access to a pond and the funds to buy the "good" fish, rather than

³⁶⁰ Tjo Kwe In, interviewed by author, Singapore, 25 May 2016; Jerome Ng, conversation with author, Singapore, Oct 23, 2016.

³⁶¹ These were taken from conversations with several koi hobbyists during the 2015 koi show in Marina Bay Sands.

the "rubbish" fish, but in general both hobbyists and farmers agree that severe restrictions on importing of fish had strangled the hobby and the koi industry.

In fact, many of the hobbyists hold a dichotomous view of diseases. None of their koi had KHV of course, because all their koi were healthy. In this sense, hobbyists agreed somewhat to the idea of a foreign invader KHV outside of their own personal collection of koi. Their own management practices included maintaining a non-stressful environment for their koi by monitoring the weather and water quality, and as far as hobbyists were concerned, this was what prevented and kept their koi healthy and thriving. While no hobbyist would admit to having KHV in their fish ponds, the fact that their fish were thriving and alive meant that they did not have KHV. The thriving and alive fish were the 'absence' of a positive marker for KHV. Without an obvious legible marker, as long as KHV was not officially tested for, it was considered absent. Most of their information about the disease came from the koi farmers in Singapore and from each other, and their opinion on KHV is that while the disease was bad it wasn't the end of the world. They were most certainly not terribly worried about the disease affecting their koi.³⁶² Environment management and direct husbandry was more important to them in maintaining the health of their koi, as evident from their talking about the weather ("It hasn't been

³⁶² Jerome Ng, conversation with author, Jul 15, 2016.

raining for two weeks!"³⁶³) and managing their illnesses ("Had many parasites after the show. Great that I managed to arrest them with salt bath and heavy parasite medication."³⁶⁴), most of which come from observing the fish's behaviour ("Now I'm studying my fish."³⁶⁵) in addition to monitoring the environment. When they talked about KHV, they talked about the disease in distant, logistical terms, rather than as a personal fear. ("KHV concerns have died down."³⁶⁶)

To hobbyists, disease is part of trying to rear and culture a living creature. "Balance" and "System" are terms used often in koi manuals³⁶⁷ and the way hobbyists behave is an attempt to keep a living dynamic system in a particular balance or within a set of parameters that is optimal for human enjoyment and koi health. When the system is out of balance, that is when disease were to occur, in the form of parasitic attacks, poor bodily functions of the koi such as gasping or lack of appetite. Instead of disease being embodied in a foreign pathogen, to a hobbyist disease is actually an imbalanced system, and it was the job of the hobbyist or an expert he might consult to bring this system back to optimal levels. The attempts of farmers to maintain this co-existence with disease of course would clash with the securitized view of disease on the farm. The balance/system that the farmers and hobbyists ascribe

³⁶³ Jerome Ng, conversation with author, Jul 12, 2016.

³⁶⁴ Ibid.

³⁶⁵ Ibid.

³⁶⁶ Benjamin Sng, conversation with author, April 28, 2017.

³⁶⁷ George C. Blasiola, *Koi: A Complete Pet Owner's Manual* (Hauppauge, NY: Barron's, 2005); H. R. Axelrod, *Koi Varieties: Japanese Colored Carp-Nishikigoi* (T.F.H., 1988); P. Stetson, *Garden Pools* (T.F.H. Publications, 1963).

to conflicted heavily with the adversarial framework that biosecurity casts on disease.

5.2.1 Factors leading to the decline of the koi industry

Many of the koi hobbyists and farmers agreed that as a market, Singaporean koi hobbyists form too small a group to truly sustain the hobby, as it requires land which is increasingly scarce in Singapore. The main influx of revenue comes instead from affluent international buyers who trust Singapore's koi farmers' reputations in choosing and handling koi, which means that koi farmers in Singapore actually are more likely to make money as koi dealers; that is, buying koi from various farms in Japan and importing them into Singapore before exporting them to other countries. However, the consensus amongst Singapore farmers is that because of extremely good global communication and better education of koi handlers internationally, koi farms have sprung up in countries that did not have them twenty years ago, such as in Malaysia. Other countries are also producing much more and are increasingly aggressive³⁶⁸ with their much larger land availability they can compete in terms of huge numbers, and, as Mathers and Marshall have stated, able to conduct a more closed-system of breeding within their farms, which Singaporean farmers find difficult. With Singapore being land scarce, and Singapore farmers being unable to renew their own farm-leases in Singapore, they were unable to compete effectively against

³⁶⁸ Lim Min Zhang, "Amid dry spell for the sector, firms are trying to tap new markets and win new customers," *Straits Times* (Singapore), June 16, 2017.

international farmers and dealers.

In addition to the strict regulations and the implementation of these regulations by the AVA, there is also evidence that the government has shifted its focus away from supporting ornamental and koi fish farmers. Land-leasing for agricultural use is regulated by the AVA, and for many farmers, there is currently "uncertainty over the lease of their premises."³⁶⁹ The government had also started a Food Fund in 2009 so as to "continue strengthening food source diversification" as part of Singapore's "longer-term strategies to enhance Singapore's food supply resilience,"³⁷⁰ and over the next years continuously pushed to "raise self-sufficiency in fish to 15 percent" of local production, while encouraging local farmers to draw on the Food Fund.³⁷¹ In the light of this more aggressive support for food fish, several of the local ornamental fish farmers have switched to rearing food fish instead of ornamental aquaculture. AVA officials have been quoted in the *Straits Times* that the AVA will "continue to work with farmers to intensify agriculture use, raise productivity and capability" with regard to food fish,³⁷² in addition to the "more than eight million dollars of the Food Fund [that] has been committed to fish farmers"³⁷³

³⁶⁹ Jessica Lim, "Ornamental fish business feels pinch of competition, strong Singdollar", *Straits Times* (Singapore), May 29, 2015.

³⁷⁰ Singapore, Agri-food and Veterinary Authority of Singapore (AVA), "Applauding Food Industry's Efforts at Food Safety Awards Night", in *AVA Vision*, 2009, issue 3, 6.

³⁷¹ Agri-food and Veterinary Authority of Singapore (AVA), "Active Support for Local Fish Farms", in *AVA Vision*, 2012, issue 2, 9; Agri-food and Veterinary Authority of Singapore (AVA), "More Super Fresh Fish from Local Farms", in *AVA Vision*, 2013, issue 1, 9.

³⁷² Jessica Lim, "Major farms switching to food fish", *Straits Times* (Singapore), July 18, 2015.

³⁷³ Singapore, Agri-food and Veterinary Authority of Singapore (AVA), "Netting Greater Support", in *AVA Vision*, 2015, issue 1, 3

for food fish farming. With less government funds allocated to help sustain ornamental fish farmers and with land-leasing difficulties, local koi farmers were finding it hard to continue farming and supplying koi domestically. The Singapore population was still considered vulnerable, but the points of vulnerability had shifted. While the reputation of healthy, disease-free fish was still important, insecurity about food resources (and sources) had become clearly a point of vulnerability to the AVA and the subsequent actions the AVA had taken were obviously to secure and guard against this vulnerability.

The international market had also fallen in demand.³⁷⁴

Singapore's ornamental fish industry's net export worth started falling soon after the KHV crisis in 2006, with the values in 2016 hitting USD 42 million, the same as it had been in 1995, more than two decades ago (see Figure 3.6).³⁷⁵ Aggressive competitors from other countries and a more globally-connected world meant that international buyers had more choice and could also buy directly from Japan. Local demand for koi and ornamental fish in general had decreased. As mentioned earlier, the prospect of introducing KHV made buyers more cautious, and with fewer young hobbyists and increasing land scarcity meant that local buyers were not buying. With a drop in local and international demand, coupled with the difficulty in continuing production in koi, the overall

³⁷⁴ Jessica Lim, "Life in a fish tank gets stuffy for exporters", *Straits Times* (Singapore), May 29, 2015

³⁷⁵ Also reported by Jessica Lim, "Major farms switching to food fish", *Straits Times* (Singapore), July 18, 2015.

koi industry in Singapore declined.

5.2.2 *Why does Singapore enact biosecurity in this manner?*

Scholars have criticized the conceptualisation of disease in a militaristic fashion, arguing that it limits the understanding of other social components³⁷⁶ and does not take into account the networked nature of disease embedded in the populations in question. Cities are not passive victims of disease.³⁷⁷ Further, some scholars have postulated that living with disease is a better management practice.³⁷⁸ Then why does Singapore still continue to utilize this older disease concept in the AVA's enactment of biopower on koi?

With other diseases such as SARS in 2003 as a positive case-study for "containment as a strategy has worked", it is logical for such a strategy to "[continue] to be employed,"³⁷⁹ as it can be easily applied for other epidemic diseases. Such a strategy would only be useful if it produces results that the AVA considers as having met its goal of keeping their target population safe. For one, the AVA reports that there are delayed appearances of KHV, that their measures are to "keep KHV at bay,"³⁸⁰ and constant surveillance meant that they could be prepared

³⁷⁶ King, "Networks, Disease, and the Utopian Impulse," 201-13; Paul Jackson, "Fleshy Traffic, Feverish Borders: Blood, Birds, and Civet Cats in Cities Brimming with Intimate Commodities," in *Networked Disease*, ed. S. Harris Ali and Roger Keil (Wiley-Blackwell, 2008), 281-96.

³⁷⁷ Steve Hinchliffe and Nick Bingham, 'People, Animals, and Biosecurity in and through Cities', in *Networked Disease*, ed. Ali S. Harris and Roger Keil (Wiley-Blackwell, 2008), 214.

³⁷⁸ Mather and Marshall, "Living with Disease?" 153-65; Lowe and Münster, "The Viral Creep," 118-42.

³⁷⁹ Peggy Teo, Brenda S. A. Yeoh, and Shir Nee Ong, "Surveillance in a Globalizing City: Singapore's Battle against SARS", in *Networked Disease*, ed. S. Harris Ali and Roger Keil (Wiley-Blackwell, 2008), 100.

³⁸⁰ "Keeping Koi Herpesvirus (KHV) at bay", in *AVA Vision*, December 2006, 11.

before the disease were to arrive. The AVA also created "operational readiness" exercises, wherein they found their officers "ready to contain and eradicate Bird Flu with minimal health risks", and the program was "robust and efficient"³⁸¹ (See Figure 4.3). Treating animal-related diseases like human-diseases in a militaristic fashion shows results such as the delayed appearances of animal-diseases, and therefore this strategy is considered successful.

The AVA also received praise for their strict biosecurity measures, which compounds the positive feedback for militaristic dealing of animal-diseases. The AVA published in December of 2005 that "experts praise AVA's food safety and biosecurity programmes," as being "sound, science-based and comprehensive."³⁸² In addition, the AVA also felt confident enough to assist other countries, such as Indonesia, with their biosecurity measures.³⁸³ The constant positive feedback and status accorded to the AVA based on these measures helped to normalise the biopolitical response to fish-diseases. Caduff has argued that when regulators and governments deal with diseases like 2009's H1N1 pandemic as an exercise for a postulated pandemic, they turned H1N1 was a "proxy for the coming pandemic,"³⁸⁴ which results in the planning and preparation for pandemics to be a given, a

³⁸¹ "AVA aces in fourth bird flu operational readiness test, "Exercise Gallus 4", in *AVA Vision*, December 2006, 2.

³⁸² "Experts praise AVA's food safety and biosecurity programmes", in *AVA Vision*, December 2005, 3.

³⁸³ "AVA assists Indonesia in controlling avian influenza", in *AVA Vision*, December 2006, 2.

³⁸⁴ Carlo Caduff, *The Pandemic Perhaps: Dramatic Events in a Public Culture of Danger* (Univ of California Press, 2015), 150.

faith-driven exercise. The fish-diseases in Singapore have also become a preparation for a bigger disease to come. Together with other animal diseases like swine flu, KHV had been geared towards the future hypothetical pandemic that the AVA believes will inevitably sweep the world. Since the future pandemic is always in the future and will never happen, treating these diseases like training is a successful practice.³⁸⁵ Strategic uncertainty is "no hindrance to the retention of authority in science or in global public health."³⁸⁶ Coupled with international praise and recognition that these current biosecurity measures work, Singapore's AVA has very little reason to change these measures, despite newer scholarly thought of disease management. Historian Mark Harrison wrote that health policy is limited when only considered in the light of security, and that it was necessary to keep in mind that security "is social in nature."³⁸⁷ By treating KHV within the narrow confines of biosecurity, and treating it the same as with food security and human health, the social fall out is unsurprising. Since koi, its diseases and the places they are from and arriving at are all interconnected, considering them as separate units resulted in ineffective security, as KHV still arrived in 2006 and the social consequence was losing the koi aquaculture industry in Singapore.

³⁸⁵ Caduff, *The Pandemic Perhaps*, 22.

³⁸⁶ Theresa MacPhail, "The Predictable Unpredictability of Viruses and the Concept of "Strategic Uncertainty", in *The Viral Network: A Pathography of the H1N1 Influenza Pandemic*, (Ithaca: Cornell University Press, 2014), 150.

³⁸⁷ Mark Harrison, "A Global Perspective," *Bulletin of the History of Medicine* 89, no. 4 (2015): 658.

Without taking into account the social effects, biosecurity enactment can thus have undesired consequences.³⁸⁸

5.3 Consequences of Biosecurity in Singapore Koi

Aquaculture

The Singapore koi farm became a microcosm of fears of biological threat. It was an extension of fears of threat to human health that grew to encompass all diseases, included animal ones, and therefore turned manifested in the biopolitical desire to police populations. This political desire had expanded to include all animals as a single system in order to control all biologicals and their emergent risks.³⁸⁹ This explains the folding of an ornamental fish disease under the umbrella of biosecurity.

When discussing disease, health officials often discuss how animal disease vectors do not respect national borders, especially in wild migrating birds.³⁹⁰ The outcome of SARS and avian flu pandemics not only exemplified that, but has become an exertion of post-Cold War anxieties of borderless threats and a shrinking planet in response to globalization,³⁹¹ with disease becoming the invisible, lurking threat in Asia and Africa, thanks to "biopolitical otherness."³⁹² When koi is

³⁸⁸ Ian Loader and Neil Walker, "Security as a Public Good", in *Civilizing Security* (Cambridge: Cambridge University Press, 2007), p262.

³⁸⁹ Bruce Braun, "Biopolitics and the Molecularization of Life," *Cultural Geographies* 14, no. 1 (2007): 6–28.

³⁹⁰ For example, Ministry of Home Affairs, "Preparing for a Human Influenza Pandemic in Singapore," (Ministry of Home Affairs, 2014), https://www.moh.gov.sg/content/moh_web/home/diseases_and_conditions/pandemic-preparedness.html.

³⁹¹ Caduff, "Visions of Biological Vulnerability," pp. 113.

³⁹² Fassin 2001.

packed and transported to their destinations, they are packed with water to keep them alive. With modern technology, the fish are transported out of Japan in a matter of hours, rather than weeks. Pathogens that might be invisible roommates to the koi therefore can spread rapidly over large geographical distances. Singapore's proximity to the rest of Asia has made the risks of biological invasion higher, as the Minister of Home Affairs had stated in 2004 that the rise of a flu epidemic was extremely likely to arise from Asia, reinforcing the belief that "disease lies in the future."³⁹³ Even though the first appearance of the KHV had been in Europe, science experts and policy makers still turn their gazes towards Asia as the hotbed of microbial activity, the source of biological fear. In doing so, human existence requires the sacrifice of animal lives in huge numbers in the name of biosecurity³⁹⁴.

Talk of "disaster"³⁹⁵ on koi farms happening in other countries have become the part of a cautionary tale and reason for heightened biosecurity fear and regulation, even as Singapore hastened to continue to preserve its disease-free status. It is yet again a reflection of similar badges of survival in human diseases, such as being stated to be Zika-free in the initial waves of the Zika virus in 2016, and the sense of distress surrounding the first announcements of the first confirmed

³⁹³ Carlo Caduff, *The Pandemic Perhaps: Dramatic Events in a Public Culture of Danger* (Univ of California Press, 2015), 183.

³⁹⁴ Bruce Braun, "Power over life: Biosecurity as Biopolitics," *Biosecurity: The Socio-Politics of Invasive Species and Infectious Diseases*, 2013, 55.

³⁹⁵ Agri-food and Veterinary Authority of Singapore (AVA), "Keeping Koi Herpesvirus (KHV) at bay," 12.

occurrences of Zika in late 2016, or in 2003 when SARS started appearing in the population. The securitized language of ornamental fish import regulations regarding disease and health certification is in fact a toned down version of the militarized effect of public health management, which was concerned about the movement of dangerous biological things, and was itself an articulation of post-Cold War tensions.³⁹⁶ Preventive quarantine of newly imported animals reflect the same sort of preventive quarantine of migrant workers allowed under the rubric of biosecurity, which highlights the geopolitical insecurities of "unrecognizable aliens capable of disrupting existing immunities, penetrating once secure boundaries at a time of deregulated exchange."³⁹⁷ Using these securitized terms allowed Singapore's health officials to "refract existing concerns about the porosity of borders and boundaries through the lens of unruly bugs,"³⁹⁸ adding to the existent anxiety of Singapore's narrative of precarious existence as I have elaborated on in Chapter 3.

Biosecurity and its implementation of biopower in Singapore not only failed to actually promote a sense of security and safety,³⁹⁹ but instead played into Singapore's post-colonial narrative of precarity, emphasizing fears of future disaster by constant reminders of the narrative of constant vulnerability. This thread of vulnerability running

³⁹⁶ Caduff, "Visions of Biological Vulnerability", 112.

³⁹⁷ Jean Comaroff, "Beyond Bare Life: AIDS, (Bio) Politics, and the Neoliberal Order," *Public Culture* 19, no. 1 (2007): 198.

³⁹⁸ Jean Comaroff, "Beyond Bare Life," 197.

³⁹⁹ Caduff, "Visions of Biological Vulnerability," pp. 115

through the ornamental fish industry from the very beginning of its inception. Vulnerability was mentioned over and over in mentions of the ornamental fish industry, and cropped up again in the talking about biosecurity management practices. Like the micro-organisms biosecurity is meant to regulate and defend against, the goalposts of safety is always evolving, growing ever out of reach. Implementing biosecurity regulations is an important issue that needs to be analysed deeper. As I had analysed over this chapter, the strict mode of implementation had unintended consequences for the koi industry and ornamental fish industry in Singapore, despite the biosecurity measures meant to secure the industry and prevent disease within Singapore's borders.

Looking beyond geographical restrictions reframes stories like the emergence of 'Western' medicine by bringing out the details of its complex beginnings.⁴⁰⁰ When analysing the attempts at biosecurity in Singapore, it is clear that the global and interconnected aspect of biosecurity and dealing with a disease that has appeared and rapidly spread internationally requires an analysis beyond Singapore's national borders. However, a complete focus on globalized science risks flattening out local diversity. The interconnectedness of a global perspective might allow for the discernment of patterns,⁴⁰¹ but state intervention has always been dependent on various local contexts.⁴⁰²

⁴⁰⁰ Mark Harrison, "A Global Perspective," *Bulletin of the History of Medicine* 89, no. 4 (2015): 657

⁴⁰¹ Harrison, "A Global Perspective," 658.

⁴⁰² Mark Jackson, "One World, One Health?" in *A Global History of Medicine*, ed. by Mark Jackson, (Oxford University Press, 2018), 2-3.

Koi and KHV have a global presence, but the localized implementation of biosecurity regulations can result in different outcomes between different countries. Localized knowledge of the aquaculture systems in Singapore is necessary to avoid elitism and a flattened rendition of the history of science in Singapore.⁴⁰³

In the local Singaporean context, biosecurity covers all kinds of agriculture, including food safety and koi aquaculture. By coming under the same umbrella of biosecurity, regulations taken to ensure food safety becomes applied also to koi aquaculture. Foucault considers food safety biosecurity a part of governmentality,⁴⁰⁴ which allows for the examination of how one can approach the duality of a state opening their economy and protecting them from world markets. With the added threat of biological risk, governmentality can be expanded into bio-power and biopolitics. Foucault (2007) showed how the state's increasing involvement in fuelling and funnelling the accumulation of riches called for new forms of power, changing from the exercise of power as top-down expression of sovereign power (the power to kill individuals) but instead bottom-up, with productive power to enable and enhance the population's own productive capacities, particularly biopower (which targets the population as a whole).⁴⁰⁵ Food security is

⁴⁰³ Sanjoy Bhattacharya, "Global and Local Histories of Medicine: Interpretative Challenges and Future Possibilities," in *The Oxford Handbook of the History of Medicine*, ed. by Mark Jackson, (OUP Oxford, 2011), 136.

⁴⁰⁴ Foucault, 2007, esp. pp. 51-71, pp. 443-55

⁴⁰⁵ Michel Foucault, *Discipline and Punishment*, trans. Alan Sheridan, 2nd ed. (New York: Random House, 1977), 9-10.

closely bound up with biopower, the power to enhance life, the specific modality of power associated with governmentality,⁴⁰⁶ which "harnesses and extracts life forces" according to "principles of discipline, efficiency and competitiveness."⁴⁰⁷ In controlling koi, the Singapore state was exerting extrapolated biopower from food security. AVA's constant discourse about food security and dependence on imports of not just food but of everything else including labour and talent. This generates a narrative amongst the public that will express concern about security.⁴⁰⁸ Koi aquaculture then becomes connected to food and health concerns in Singapore, a practice that is not global since Japan does not follow the same trajectory.

The story of Singapore's biosecuritization of koi is intensely local. While Japan's disease management protocols were translocated to Singapore, the translation and adaptation to the local framework of vulnerability to externalized disease resulted in vastly different changes in aquaculture practices. Where Japan considered social groups like farmers when implementing disease management regulations, the Singapore government were focused more on the vulnerable state of Singapore's reputation in the ornamental fish industry, resulting in a

⁴⁰⁶ Koh, Sunhui and Kate Barclay (2007) "Traveling through autonomy and subjugation: Jeju Island under Japan and Korea," *The Asia Pacific Journal: Japan Focus* 5(5), 2007, 1.

⁴⁰⁷ Aihwa Ong, "Introduction: Neoliberalism as Exception, Exception to Neoliberalism", in *Neoliberalism as Exception: Mutations in Citizenship and Sovereignty* (Duke University Press, 2006), 13.

⁴⁰⁸ Bestor, Theodore C. "Constructing sushi: Culture, cuisine, and commodification in a Japanese market." *Cornell East Asia Series*, 106 (1999): 167

disconnection in the networked nature of the social groups involved in ornamental fish industry. Flattening this act into globalization runs the risk of losing the localised narrative, and risks reproducing globalization narratives instead of critique.⁴⁰⁹ Localised narrative is not the only important aspect of this research. Place is also important⁴¹⁰ when considering the practices of people involved in the koi aquaculture. So when the koi's body become medicalized, it can be securitized and pulled under the state's control, but not under a global control.

Unlike other countries where food security can be understood to involve "requiring government support for domestic producers to ensure some measure of self-sufficiency,"⁴¹¹ Singapore instead promotes a different narrative, emphasizing the necessity of dependence on global trade in order to ensure food security. This aligns somewhat with the international sphere of governmentalities, which "posit free trade as the best way to secure supplies."⁴¹² This extremely networked form of governmentality allows various food sources to be cultivated at the same time and thus increases food security. However with the many sources of food, this increases the number of sources to be insecure about. In being so networked to increase security, Singapore's economy is rendered vulnerable. The ornamental fish industry was but one of the

⁴⁰⁹ Sarah Hodges, "The Global Menace," *Social History of Medicine* 25, no. 3 (2012): 724.

⁴¹⁰ Warwick Anderson, 'Excremental Colonialism: Public Health and the Poetics of Pollution', *Critical Inquiry* 21, no. 3 (1995): 652.

⁴¹¹ Kate Barclay and Charlotte Epstein, "Securing Fish for the Nation: Food Security and Governmentality in Japan," *Asian Studies Review* 37, no. 2 (June 2013): 227.

⁴¹² *Ibid.*

many industries that Singapore cultivated to secure state security. When koi was shown to be a risky industry with the very contagious and omnipresent threat of KHV, it opened up the whole ornamental fish industry to biological risk. In turn, a biologically risky industry could impact Singapore's reputation of having healthy products. In trying to exert control over the disease threatening the industry, the koi fish industry was exposed to risk.

Singapore's medical establishment utilized the military envisioning of disease as a result of post-Cold War anxieties over national security. Singapore's biosecurity measures were developed in line with this narrative in an effort to keep invading disease out of Singapore's national borders. With this history, human disease pathogens were made to be equivalent with animal diseases, which threatened two different industries, the food industry and ornamental fish industry. As disease-causing pathogens inflicting both industries were conflated, strict implementation of biosecurity on food-producing farms were also implemented on the Singapore koi farm.

Scientific knowledge of KHV's biological properties was translated into koi and their water being considered as very infectious, and a very large biological risk to all fish. Localised adaptation of Japan's disease management into strict regulations were formulated specifically for koi, which in turn made koi extremely difficult to import and export. The chance of infecting non-koi fish with KHV also added

complications to the rest of the ornamental fish industry.

Thanks to the strict quarantine and culling demands of biosecurity in koi farming and splitting of aquaculture practices into separate functions, Singapore farmers and hobbyists felt that the government was overreacting to KHV and its risks. The small domestic market for koi was not enough to continue to sustain the koi industry in Singapore, and coupled with rising competition from neighbouring countries, strict biosecurity regulations that limited farmers' ability to continue their farming businesses easily, the koi industry went into a decline.

5.4: Conclusion: Translocation of Koi and KHV

Koi aquaculture practices in Singapore prior to 2006 involved a network of koi farmers and koi hobbyists, consulting occasionally with first PPD, then AVA officials, and mostly with Japanese breeders. Koi was allowed to move freely in and out of Singapore. After the translocation and translation of Japanese protocols in KHV-management into Singapore's disease-management framework however, much of the koi aquaculture practices in Singapore changed. Koi was no longer freely allowed to move, and koi breeding and koi importing was split and separated into two clearly delineated practices. Koi farmers also started to shift their focus from solely koi husbandry to other aspects of the aquaculture industry, be it in food fish aquaculture, water feature consultation or others. In contrast to the ground-up growth of the

ornamental fish industry as shown in Chapter 3, the translation of Japan's disease management protocol into the emergent biosecurity regulations in Singapore resulted in a top-down implementation of biosecurity and subsequent decline in the industry.

The translocation of knowledge about Japanese KHV-protocols and subsequent translation by Singapore's AVA officials allowed biosecurity to emerge and be enacted within the ornamental fish aquaculture industry. While the process of making KHV legible was scientific, the knowledge was translated into disease management protocol in Japan that was one step removed from scientific understanding. When this disease management protocol from Japan was transferred from Japan to Singapore's aquaculture industry, AVA's motivation in translating the protocol into biosecurity was aimed more in keeping Singapore's industry disease-free than in applying the scientific knowledge of KHV to koi aquaculture specifically.

Chapter 6: Conclusion: The different bodies of Koi in Singapore

The translocation of koi is not just the physical movement of a colourful fish from Japan to Singapore. Moving koi brought along the koi's relationships with its environment, which humans have translated into knowledge and then into aquaculture practice. Human actors had different motivations for learning particular knowledge, and had very different outcomes in the aquaculture industry based on whether their interpretation of knowledge was based on scientific knowledge or not. In addition, translocation of koi needed translation to be successful—translation of the aquatic environment into systems and practices on farms was necessary in order to have the required expertise and knowledge to sustain and maintain koi.

Translation of disease knowledge that had been transferred transnationally resulted in the emergence of biosecurity. Its emergence had the unexpected consequence of the decline of the ornamental fish industry. This is due to the fact that koi embodied so many kinds of knowledge, and depending on which human actor is looking at it, the kind of knowledge that can be derived from koi could be translated into scientific or non-scientific practice.

The many kinds of bodies koi embodied are all tied to the ornamental fish industry. Koi can be perceived as the productive body, in producing both offspring and economic value, sometimes in

producing social status. Another body is political, signifying the bilateral ties between Japan and Singapore, and at the same time embodying the perception of Japanese expertise. Several PPD officials like George Tay had started working with koi because of both the political status of particular koi and the interest in a koi industry, but also farmers like Pay Bok Seng had noticed koi and the potential market in either attempting to breed or to import the fish.

The koi's body was also a repository of knowledge. The koi industry also grew with the ornamental industry and from the industry parts developed into different small institutions to become centres of knowledge, bringing together international experts and researchers in the Aquarama, and the local journal *Singapore Journal of Primary Industries* that consolidated both local academics and local researchers in the government regulatory level. Here, experiments about ornamental fish were localised and specific to Singapore's scientific and industrial milieu, and knowledge generated from these experiments were translated into local aquaculture regulations. The koi fish embodied this localised aquaculture knowledge. The Aquarama on the other hand hosted an international sharing of knowledge, with regulations and new scientific knowledge that could be applicable to people within the industry of Singapore looking to export to other countries, or how new practices could improve local farming practices. Aside from these somewhat formal centres of knowledge, koi farms in Singapore also

became locations of localised vernacular knowledge. Local farmers also translated knowledge of cultivating ornamental fish in water to aquaculture practices for translocated koi. While most of the farmers were not formally educated in fish aquaculture, their expertise and experience in the rearing koi had become recognised by other hobbyists, and thus these farmers served as not only go-betweens or translators between Japanese breeders and hobbyists, but also as a repository of knowledge, practices and experience that the hobbyists could consult. Contemporary hobbyists did not consult Singapore academics, and instead contemporary scientists in Singapore were considered unimportant and unnecessary to the koi hobby in general. The roles of the people involved around the koi fish were not static and changed over time.

The koi fish also was a host body to disease. The diseased and dying body of the koi prompted the generation of knowledge of KHV, and the knowing of KHV was translated into a diagnostic tool for the presence of KHV. Its idealised body was a state that farmers and hobbyists attempted to achieve by manipulating and recreating the Japanese aquatic environment for the koi. Scientific knowledge about koi's relationship with its environment, both biotic and abiotic was generated in order to understand it and translate it into aquaculture practices in Singapore.

In this thesis, I attempted to answer several research questions.

First, how and why did ornamental aquaculture practices in Singapore change over time? How and what were the factors that allowed the development of koi culture into the socially important practice it is today? Much of the aquaculture practices in Singapore were influenced first from the need to gain control over the koi's health via manipulation of water parameters. Several of these parameters were pinpointed as critical for koi health, and Singapore hobbyists sought to manipulate them to recreate the Japanese aquatic environment. However, these manipulations had to be adjusted to account for Singapore's different environment, hence changing the practices in cultivating koi in Singapore. Furthermore, the understanding of KHV and how it can be detected was translated and then integrated into Singapore's pre-existing protocols for dealing with animal disease and resulted in regulations that impacted and restricted koi cultivation practices.

Singaporean scientists focused on reusing the same water volume and used finer and more detailed properties of water to enhance their ability to keep reusing water. Water quality was also perceived by hobbyists and farmers to be vitally important to the husbandry of their koi, both in terms of maintaining the good quality of their koi and preventing diseases. It was here that disease-causing pathogens started to emerge as a water property that affected fish. State intervention to prevent KHV was enacted within Singapore's framework of dealing with diseases, and this translation of regulations from other disease to

KHV resulted in further modification of koi cultivation in Singapore.

Koi identified with positive presence of KHV were killed, and koi breeding and koi selling was separated into two distinct functions.

Second, what did Singapore take from Japan's koi cultivation practices, and how did they change it? Second, how did aquaculture practices differ between Singapore and Japan? Due to the social importance Japan had acquired in the 1980s, Singapore tried to learn from Japan in various ways, one of which was the aquaculture practices of koi. These had to be translated and adapted into useful practices for the Singapore situation. Singaporean hobbyists, farmers and even some regulatory officials view Japan as the centre of knowledge for koi breeding, attributing it in part to the geography, climate and the familial structure in Japan. Some hobbyists believe that because Japanese farmers have been farmers for generations and therefore they knew secrets that Singaporean hobbyists would never be able to catch up on. Water parameters such as temperature and softness were initially manipulated to imitate the Japanese climate. Many of these parameters and practices had to be adapted to Singapore. Furthermore, in the wake of KHV in 2006, Singapore learned and adapted the Japanese protocol for dealing with and controlling KHV within Singapore's framework of disease control. Biosecurity regulations within Singapore's disease management protocol was translated and applied to the Japanese protocol for KHV management. Singapore learning from Japan

improved bilateral ties. At the same time, Singapore learning how to effectively keep and maintain koi in both looks and health meant they continue to be a good export market for koi, especially since Singapore acts as an intermediary market globally.

The third and final question was how was scientific knowledge generated in the context of koi aquaculture? In this thesis I found that there were many kinds of knowledge being created with koi aquaculture. Normal scientific knowledge was generated in institutions such as labs, and while vernacular science was produced outside of these institutions such as on farms. Certain kinds of knowledge were dependent on others. For example, there was the knowledge gained after conducting a test (finding the positive presence of KHV after using PCR as a diagnostic tool), knowledge needed to make the test (the scientific knowledge generated in understanding KHV and developing PCR as characterisation then diagnostic tool). Then a different set of knowledge that is about the ecological situation of the fish in order to enable it to reproduce, maintain its healthy status. This knowledge is again translated and applied in government regulations that inform and regulate farm practices. These kinds of knowledge are all inter-related and inform each other, and take various forms in transmission, such as via scientific journal publications, or by translocation internationally and subsequently translated into intelligible forms that could be applied as koi aquaculture practices.

The different categorizations of the kinds of knowledge and how they were generated allowed a more detailed examination of the human social groups interacting around the koi. They highlighted the transmission direction (from Japan to Singapore), but also showcased exactly where and how particular kinds of knowledge was adapted into different practices. Such fine-scaled examination meant that I could better get at the inter-group interactions of people such as how Singapore regulatory officials interacted with koi farmers, and even how these relationships changed over time. Scientific knowledge of KHV also helped to parse out the definition of fish disease, translating ambiguous symptoms into a definitive presence or absence.

Much of the effort in generating knowledge of all categories were in the aid of maintaining koi in one specific valuable state. Despite its appearance as a beautiful living koi, its very existence is in reality a complex set relationships with disease pathogens, its environment and the koi's relationships with various groups of people. The translocation of koi from Japan to Singapore provided the impetus for scientific knowledge generation about koi and its complex relationships.

Knowledge about koi was generated via translocation and in the act of translation when knowledge was transmitted and adapted between social groups of people, and this resulted in the emergence of biosecurity within ornamental fish aquaculture in Singapore.

Figures

Figure 1.1: A table listing a few of water parameters that concern fish hobbyists and farmers.

A list of some water parameters
Oxygen
Carbon Dioxide
Nitrogenous compounds (including nitrates, nitrites, ammonia and urea)
Metal ions
Salinity or salt levels (sodium chloride, calcium ions and other salts)
Parasites
Bacteria (including nitrifying bacteria, pathogenic bacteria)
Temperature
pH (a measure of acidity)



Figure 2.1: Set-up of a handmade filtration system by Jerome Ng for his koi pond. Water passes through the white-PVC pipes through the large plastic tubs, and are allowed to drip down below through the plastic baskets that hold yet more filter material. (Photo credits: Jerome Ng).



Figure 2.2: Jerome's koi pond. The hose entering the pond from the right pipes in air to a bubbler to aerate the pond. The wooden slats are a built-over platform that covers part of the pond. This pond is on Jerome's parents' property; he has no other pond (Photo credits: Jerome Ng).



Figure 2.3: Above is pictured Jerome's Tsurumi pump, one of the preferred brands for koi hobbyists thanks to the ability of the pump to withstand the long hours and large volume output. (Photo credit: Jerome Ng)



Figure 2.4: An example of a water cooling unit, on Diamond Koi farm. This is used for the koi that had just been imported. (Taken April 28th 2017)



Figure 2.5: the inside of the custom-made filter units in the Diamond Koi farm. The net-like plastic structure in the tank are physical filters, and the water is pumped through it via the PVC pipes shown on the right.

The green net over the water surface on the right is to prevent koi from jumping too high and out of the tank. (Taken April 28th 2017)



Figure 3.1: The large aquarium tank that is immediately visible on entering the hall of Aquarama 2015. (Taken 29 May 2015).



Figure 3.2: Close up of the aquarium tank in Fig 3.4. It is a close up of various coral species, and many marine ornamental fish, including blue tang. (Taken 29 May 2015)



Figure 3.3: Image of Aquarama 2015 International fish competition. Rows of fish tanks entered and judged for competition and available for viewing. The tanks are lined with bright blue material and lit overhead with florescent bulbs. (Taken 29 May 2015).



Figure 3.4: Goldfish which had won 2nd prize in their category, noted with a paper star pasted above their tank (left) and Siamese Fighting Fish (*Betta splendens*) which had won 1st prize. (Taken 29 May 2015).



Figure 3.5: Picture of Hai Feng Feeds stall, the only stall in Aquarama 2015 that was dealing with koi related items. (Taken 29 May 2015).

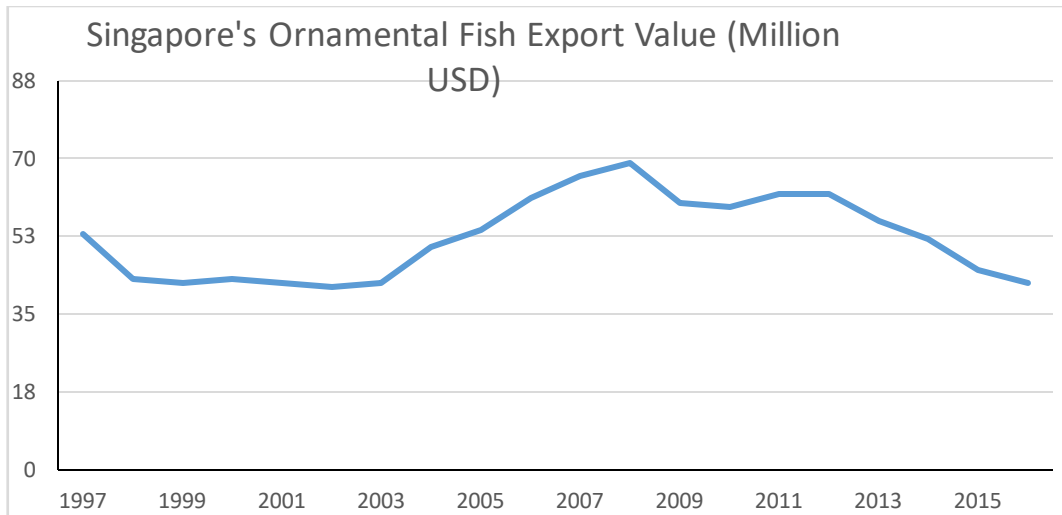


Figure 3.6: Graph of Singapore's Ornamental fish export value (USD million) over time from 1997 till 2016. Statistics were taken from the United Nations Commodity Trade Statistics Database, and compiled into this graph.

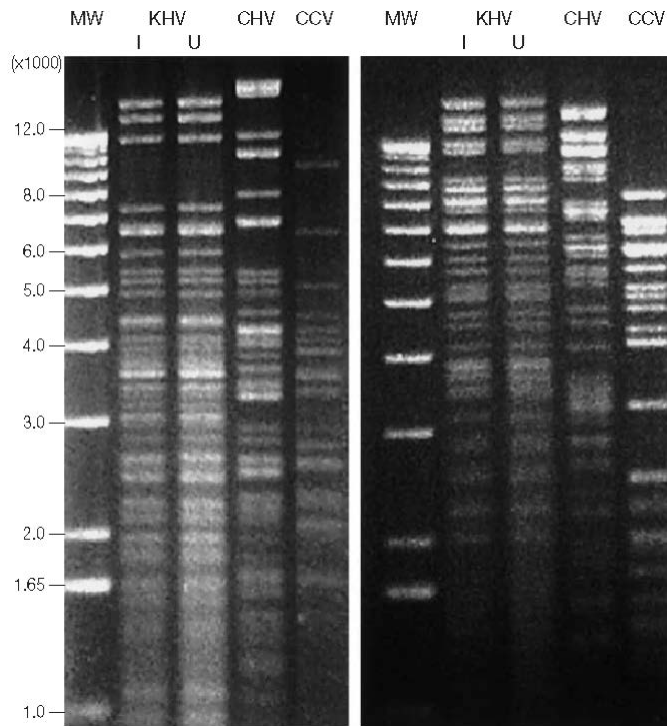


Figure 4.1: Photographs of the genomic DNA bands from virus samples taken from infected fish from Israel (KHV-I), USA (KHV-U), CHV and CCV. (Gilad et al. 2002, Figure 2).



Figure 4.2: Photographs of juvenile koi fish with KHV (A), with discoloured patches on the skin of the fish indicated with black arrows, (B) showing the sunken eyes of an infected fish (left) compared to the normal eyes of a healthy koi (right), and (C) showing the white and discoloured gill filaments of the koi which indicates dead gill tissue, indicated with black arrows. (Hendrick et al. 2005, Fig. 1)

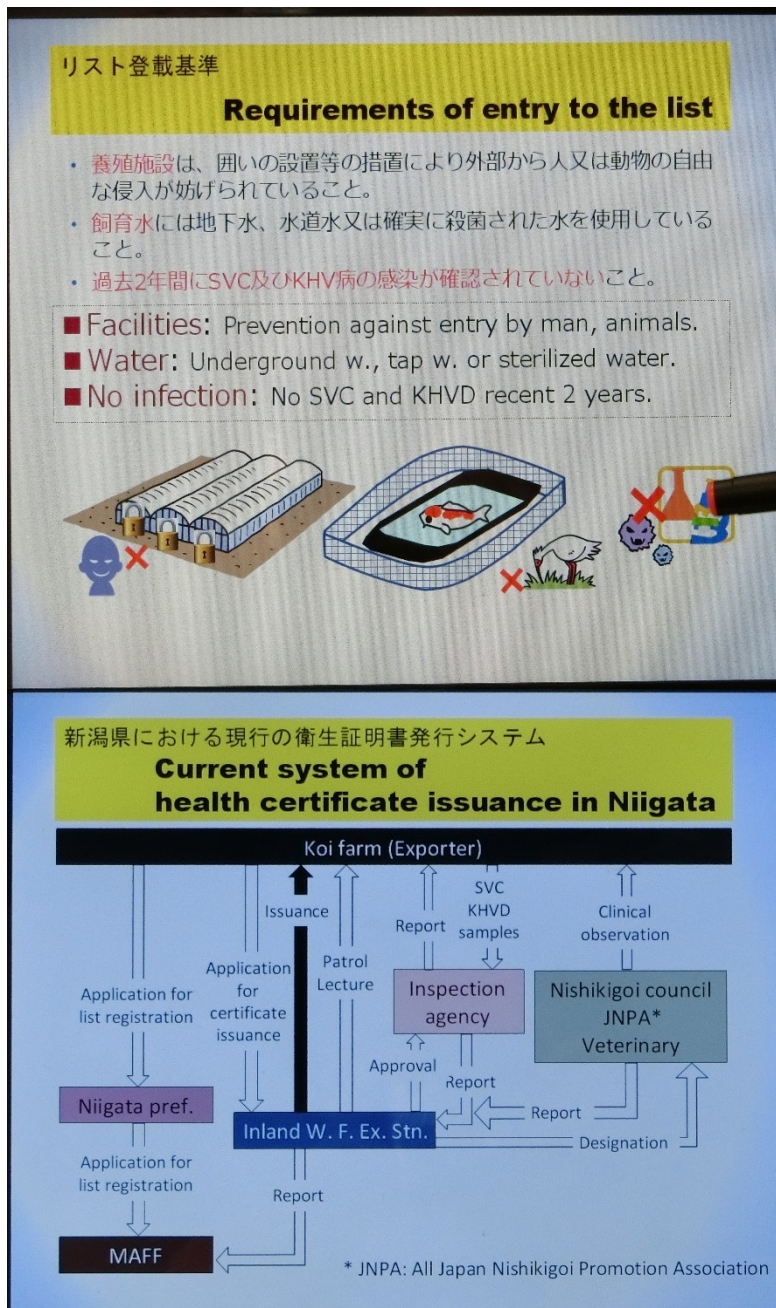


Figure 4.5: Basic requirements for entry to the list of approved koi for export (top) and the current system of issuing health certificates in Niigata, summarized in a diagram (bottom). (Photos taken of a slide presentation with permission from Dr Sato Shoh, November 2, 2016)

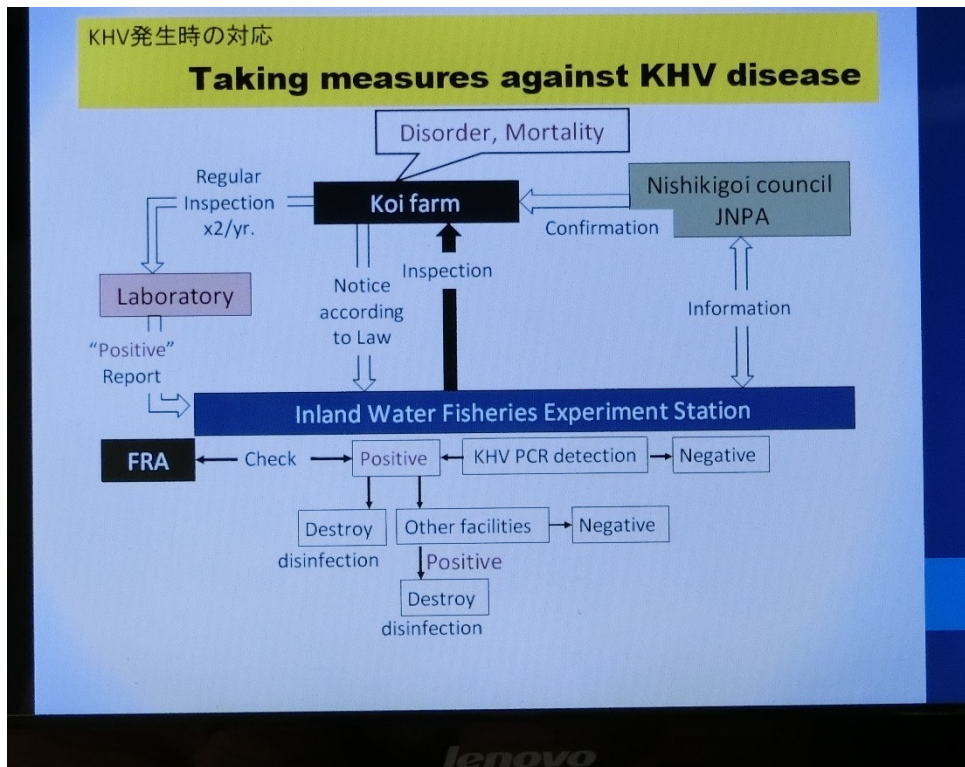


Figure 4.6: A diagrammatic representation of how the Niigata Experiment Station implemented biosecurity regulations to prevent KHV from spreading. (Photo taken of a presentation slide with permission of Dr Sato Shoh, November 2, 2016)

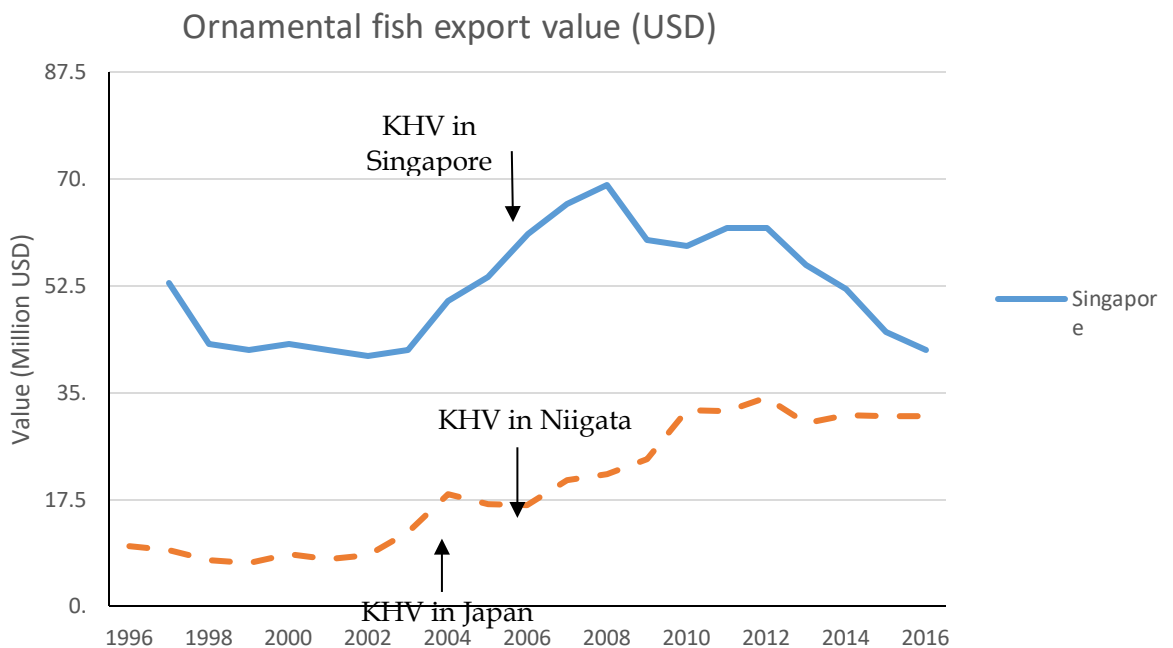


Figure 4.7: the value of Japan's ornamental fish exports (red dotted line) plotted on the same graph as Singapore's (blue solid line) from 1996 to 2016. Arrows indicate when KHV was detected in Singapore & Japan. Japan's exports were generally lower in value for the same time period, with a slight dip after 2004, but also showed a general increasing trend

over time. (Data taken from United Nations Commodities Trade statistics database.)



Figure 4.8: A photo of the yellow and white koi breed that the Niigata Experiment Station had bred. It was named 黄白(yellow white). This breed was meant to have a similar colouration pattern to that of kohaku (紅白), one of the standard breeds of koi that has red and white colouring. These koi were on display at the Nishikigoi Museum in Ojiya city, Niigata, Japan. (Taken on October 28, 2016)



Figure 4.9: A sample of a second breed of koi that the Niigata Experiment Station was trying to breed. The desired colouration was the mango-yellow and white colouration – the rest of the koi are undesired siblings. (Taken on November 2, 2016)



Figure 5.1: Large blue tubs meant to be shoe-baths at the entrance of Nippon Koi Farm. (Photo taken September 30, 2015).



KHV-infected Koi with discoloured gill edges.

Keeping Koi Herpesvirus (KHV) at bay

Ornamental fish traders dealing with Kois in Singapore are concerned about Koi Herpesvirus (KHV). KHV was reported as a significant disease of Koi in Israel, Europe and United States in 1998, and caused the Koi Mass Mortality Syndrome in Indonesia in June 2002.

Preventing the import of KHV-infected Koi

Ornamental Fish Exporters Scheme in 1983. Only exporters with a consistent track record of management practice on hygiene and sanitation, and fish quality can qualify for this accreditation, AVA provides members with guidelines through its Code of Practice. Members are at liberty to exercise on top of this Code of Practice, their own quality control measures to ensure that only good

FISH HEAD

Figure 5.2: An image of the December 2006 *AVA Vision* on the Koi Herpes Virus (KHV). The large and graphic image of a dead koi and diseased gills was prominent on the second to last page of this issue of *AVA Vision*.

AVA aces in fourth bird flu operational readiness test, "Exercise Gallus 4"

02 CORPORATE CUTS

Carried out on 4 October 2006 and involving some 230 personnel from AVA, Ministry of Health, Singapore Civil Defence Force and external cullers from cleaning and construction companies, "Exercise Gallus 4" found AVA ready to contain and eradicate Bird Flu with minimal health risks and its systems robust and efficient.

The emergency response team's swift response and full compliance with personnel protection procedures resulted in a smooth interagency

coordination and an efficient decontamination process. The external cullers quickly adapted to the culling process while observing the required biosafety protocols. This group forms an effective alternative pool of manpower reserve should the need for mass culling arise.

Operational refinements such as ensuring a better fit of personnel protection equipment (eg. boots and goggles) for the comfort of the cullers were among some areas for improvement identified through this exercise.

Figure 5.3: Extract from the *AVA Vision* December 2006. AVA writes of the fourth exercise in preparing for the event of avian flu incidences.

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