Australian Government
Department of Agriculture and Water Resources

Report into the cause of white spot syndrome virus outbreak in the Logan River area of Queensland – December 2016

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Department of Agriculture and Water Resources
Postal address GPO Box 858 Canberra ACT 2601
Telephone 1800 900 090
Web agriculture.gov.au

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Introduction

On 1 December 2016, white spot syndrome virus (WSSV) was confirmed on a prawn farm located on the Logan River in South-East Queensland. The Department of Agriculture and Water Resources has undertaken inquiries into the potential pathway of WSSV onto prawn farms in the Logan River area. This report identifies the plausible pathways of entry of WSSV into the Logan River area. The pathways identified and assessments made within this report only reflect the information known and available to the department at the time of publication on **22 May 2017**. This report may be updated, if and when, new or relevant information becomes known to the department. This report does not cover any aspects of how the response to WSSV was undertaken nor the decision to suspend the importation of prawns into Australia.

Background

Prawn Farming in Australia

Prawn farming in Australia is currently concentrated on the east coast of Australia with 24 farms located in Queensland and three in northern NSW. Most farms rely on wild-caught mature broodstock sourced from Australia's north coast. The broodstock are maintained in hatcheries where they mate and lay eggs. The early stages of the prawn life-cycle are maintained and reared in tanks within the hatchery. When the prawns reach the post-larval stage, they are freighted to the grow-out farms for stocking into ponds.

What is White Spot Syndrome Virus (WSSV)?

White spot disease (WSD) is a highly contagious viral disease and usually lethal, with cumulative mortality in farmed prawns reaching 100 per cent within two to seven days post infection. Diseased prawns show typical clinical signs – although not pathognomonic – such as a dark-reddish colouration of the whole body and white inclusions (spots) on the carapace and appendages, and lethargic behaviour with loss of appetite. It has a very broad host range with all decapods sensitive and annelids, arthropods or molluscs can be vectors.

The causative agent of WSD, i.e. the White Spot Syndrome Virus (WSSV), a double stranded DNA virus (Whispovirus, Nimaviridae), first emerged in Northeast Asia in 1992 - 1993. The disease spread rapidly throughout Asia and now occurs in most prawn producing countries. The primary pathway for spread of WSSV is thought to have been through the movement of prawn broodstock and post-larvae (Walker and Mohan 2009).

As recently as 2011 - 12, new outbreaks of WSSV in farmed prawns have occurred in Saudi Arabia, Mozambique and Madagascar (Le Groumellec 2012; Tang et al. 2013). Genetic analysis from these three outbreaks indicate a common lineage, suggesting the WSSV outbreaks in these locations were from a common source, likely the environment (Tang et al. 2013). WSSV is known to transfer between the natural environment and farmed prawn populations in most parts of the world.

The Department of Agriculture and Water Resources undertook a comprehensive Import Risk Analysis (IRA) for imported prawns and prawn products, which was released in 2009. The IRA recommended import conditions to manage the risks associated with a number of diseases, including WSSV. Post border measures, including preventing the use of raw prawns as bait and farm biosecurity controls, were also recommended.

WSSV pathways and spread

What are the potential pathways for WSSV introduction to the Logan River area?

Expression of WSD in an aquatic animal requires:

- susceptible hosts
- presence of the pathogen, WSSV
- appropriate environmental conditions.

The Logan River area contains crustacean species that are susceptible to WSSV. These occur on prawn farms and in marine and estuarine environments. The subtropical environmental conditions in the area are also appropriate for WSSV to replicate and cause disease within susceptible hosts. The remaining requirement for WSD to occur is presence of the viral causative agent.

There are five possible pathways, which may have led to the introduction of WSSV to the Logan River area. They are:

1) The virus was introduced from raw imported prawns being used as bait.
2) The virus was introduced via imported aquatic feed or feed supplements.
3) The virus was introduced through diseased broodstock or their progeny.
4) The virus was introduced via a human element, including the importation of associated equipment.
5) WSSV was present in Australia, but had not been detected previously.

The entry pathways of WSSV to the Logan River area outlined above will be explored further in this report, including the known scientific information regarding each pathway and an assessment of the likelihood of each pathway causing the December 2016 WSSV outbreak. Further information obtained through the department's inquires that are relevant to the assessment of pathway plausibility are also summarised.

How does WSSV spread between farms?

WSSV has spread to seven prawn farms located on the Logan River over a period of approximately two and a half months (1 December 2016 to 13 February 2017). The potential means of transmission of the virus between susceptible animals includes:

- vertical (parent to progeny), from broodstock to post-larvae
- horizontal (among individuals), including via:
  - oral consumption of infected tissue
  - water-borne (spread in open ponds, the viability of free virus in sea water is 3 - 4 days).

These modes of transmission can apply to pathways for spread between farms.

The following are considered to be possible routes of spread of WSSV between the farms and within farms on the Logan River:

- **Oral transmission** e.g. farmed tiger prawns and resident crab populations eating infected species. Horizontal transmission is the most effective avenue for transmission of WSSV via an infective dose. This could potentially happen in the affected area if the wild prawns that enter the farm when the ponds were filled with water were infected.
- **Exposure to water containing viable WSSV** (water-borne transmission). Water is considered an effective vector for the transfer of the virus, but not as effective as oral transmission. Each of the farms take unfiltered water into an intake channel, which are filled with a range of wild crustaceans, including greasyback prawns and glass shrimp. As the wild populations breed and grow in the inlet channels, the potential exists for infected crustaceans to release WSSV into the water, which would subsequently move into the production ponds when the ponds are topped up. All the infected farms sourced their water from the Logan River and immediately adjacent area of Moreton Bay.
- **On-farm biosecurity protocols.** An absence of, or inadequate level of, on-farm biosecurity practices and controls increases vulnerability to initial contamination and may enable the transfer of WSSV both within and between farms.
- **Bird predation and activity.** Birds may transfer WSSV between ponds when feeding on dead and dying prawns. Birds are attracted to the ponds containing sick prawns because the sick and dying prawns congregate around the side of the ponds where there is more oxygen in the shallows at the edge of the pond.
- **Mechanical transfer via on-farm equipment or operational procedures.** Water spray from pond to pond from paddle wheels (providing oxygen to ponds).
- **Water run-off.** During processing operations, such as packaging, sorting, freezing and cooking, water run-off could be contaminated with WSSV.

WSSV outbreak in the Logan River area – a summary of events

Prior to 1 December 2016, Australia was considered to be free of WSSV with the only previous detection being an outbreak at two aquaculture facilities in Darwin in November 2000. It was determined that the outbreak of WSSV at the Darwin aquaculture facility was caused by the inadvertent use of imported prawns intended for human consumption as feed. On that occasion the virus was considered contained to the facilities and immediate vicinity and was eradicated. Surveillance of susceptible crustacean species demonstrated that WSSV had not established in Darwin Harbour.

Initial detection and confirmation

On 22 November 2016, a prawn farm located on the Logan River south of Brisbane notified Biosecurity Queensland, an operating division of the Queensland Department of Agriculture and Fisheries, of unusual mortalities of prawns in one of their ponds. The farm concerned was one of two family owned prawn farms in close proximity to each other and adjacent to the lower reaches of the Logan River. Further unusual signs of disease were observed in the following days, culminating in confirmation of the presence of WSSV from positive laboratory tests by the Australian Animal Health Laboratory (AAHL) on 1 December 2016.

On the first infected property the first signs of infection were observed in the ponds furthest from the river. Water was sourced from the Logan River, where it was then coarsely filtered to remove plankton but received no other treatment. Wild prawn nauplii (a larval stage of prawns) often enter the property with the intake of water and it is not uncommon for other prawn species (including greasyback prawns and banana prawns) to be collected at harvest.

Progression of the outbreak

Following the initial confirmation of WSSV at the first farm on 1 December 2016, the outbreak continued to spread to the other farms on and in close proximity to the Logan River with the seventh and final farm confirmed as an infected property on 13 February 2017. Whilst spread of the disease can likely be attributed to a number of factors such as common water exposure, movement by wild animals and birds, sharing of equipment and common production inputs, this report focusses on the initial outbreak.

Observations from the outbreak

The feature of ponds furthest from the river being the first ponds to be infected on each farm was first reported by an independent aquaculture consultant, Dr Ben Diggles. This feature is considered anomalous and unexpected. It was noted that these ponds were amongst the first to be stocked so the fact that they were first to experience clinical disease may be due to the prawns reaching a particular life-cycle stage or stocking (biomass) density first. Alternatively, it has been suggested that these ponds were at the end of the inlet channel where a large population of glass shrimp could be found. The fact that these ponds were the first to be confirmed infected may be related to a large number of putatively infected wild crustaceans either entering these ponds or being resident immediately adjacent in the inlet channel and releasing virus into the water that subsequently enters the production ponds when the ponds are topped up.

When did the department become aware of WSSV in the Logan River area?

The Australian Chief Veterinary Officer was notified of the suspect detection of WSSV on 30 November 2016 by the Queensland Chief Veterinary Officer and the confirmed infection on 1 December 2016. Biosecurity Queensland coordinated the response to the outbreak as the lead agency and were supported by the Department of Agriculture and Water Resources. The Department of Agriculture and Water Resources also set up an Incident Management Team to coordinate departmental activities associated with the WSD incident.

Analysis

An investigation into the outbreak was commenced on 13 December 2016. The investigation focussed on identifying all of the potential pathways that the virus may have been transmitted via and assessing the validity or otherwise of each of these pathways. This approach relied heavily on advice provided by departmental scientists who had visited the affected farms with investigators.

Investigators and scientists commenced a range of activities and inquiries designed to assess the likelihood of the five potential pathways as sources of the virus.

WSSV pathway scenarios

Pathway 1: the virus was introduced from raw imported prawns being used as bait

Investigation

Retail purchasing of imported raw prawns

On 14 and 15 December 2016, investigators purchased 19 raw imported prawn products from 13 retail outlets, mostly within a 10 kilometre radius of the infected properties. Later analysis of these products by AAHL established that 14 of the 19 products tested positive to WSSV.

Use of raw imported prawns as bait

On 19 December 2016, investigators visited a number of sites on the Logan River commonly used by land based anglers. The purpose was to gauge the use of prawns as bait in the river and locate any discarded packing that may indicate such use. In the course of that activity two recreational fishermen were located at Skinners Park, fishing with raw imported vannamei prawns for human consumption. Skinners Park is located on the northern river bank of the Logan River, approximately five kilometres upstream from the first infected farm.

The fishermen admitted that this was the third occasion that they had fished in the river using prawns for human consumption but claimed they were unaware that prawns of this nature should not be used as bait. The prawns used by the fishermen on this occasion were from a bag that was labelled 'for human consumption'. The remainder of the prawns were provided to investigators who traced the import history of the prawns via batch and lot code information on the packaging.

It was ascertained from those inquiries that the prawns were imported by a known importer in June 2016. Viral testing for WSSV was undertaken at that time of import and following a negative test for the presence of WSSV they were released for sale.

Samples of the prawns obtained from the fishermen were sent to the Elizabeth Macarthur Agricultural Institute (EMAI) for WSSV testing and results confirmed that the prawns were positive for WSSV. Samples were later provided to AAHL by EMAI, which also returned positive results for WSSV.

The department has actions underway relating to non-compliance with import conditions concerning raw imported prawns.

Between the 26 and 28 January 2017, investigators conducted a survey of fisherman fishing in the Logan River. The survey sought information on the use of bait in the river, with an emphasis on any use of prawns for human consumption. A total of 144 anglers were interviewed, of which nine reported they had used raw prawns for human consumption as bait.

Assessment

Based on the information above it is evident that some raw imported prawns recovered from retail outlets proximal to the infected properties tested positive to WSSV. It is also known that to some extent these WSSV infected prawns are used by fishermen in the river and are also discarded or fed to birds following the fishing activity. Using prawns as bait for fish represents a possible entry and exposure pathway for susceptible crustaceans.

Raw prawns imported to Australia are required to be shelled, with their head removed, which reduces the viral load of infected prawns. Individual imported raw prawns, if infected with WSSV, are therefore likely to have a lower viral load (compared to whole infected prawns) and if used as bait may result in a lower rate of viral introduction into the environment. Environmental sampling and testing in the Logan River and Moreton Bay area has been undertaken by Biosecurity Queensland, with close to 20,000 samples taken and tested for WSSV. A small number of these samples have tested positive (approximately 250, noting that this figure is based on testing of representative samples). WSSV has been detected in the Logan River, North Moreton Bay and the Brisbane River. In addition, approximately 1000 samples have been collected in Northern Queensland locations all of which have tested negative for WSSV.

As part of the investigation into the potential cause of the WSD outbreak whole genome sequencing of WSSV isolates is underway. This work is being conducted by the Australian Animal Health Laboratory (AAHL).

To date, preliminary analysis of three samples of WSSV from Queensland, obtained from two of the infected premises on the Logan River and from a trawl site in northern Moreton Bay showed that the WSSV genome assemblies shared greater than 99.9% nucleotide identity with each other. These results indicate that WSSV detections from the two infected premises and northern Moreton Bay are likely to be from a single source and not from multiple WSSV incursions.

A comparison was also undertaken between eight WSSV genomes available in the National Center for Biotechnology Information (NCBI) GenBank, one WSSV genome sequence obtained from an imported prawn and the WSSV sample from northern Moreton Bay. The WSSV genome assembly from northern Moreton Bay shared 84.5% to 99.2% nucleotide identities with the above samples. These results are not sufficient to determine the origin of the WSSV identified in Queensland. Genotyping work is also being undertaken by Queensland. This work is not complete.

Additional whole genome sequence data will be required from overseas before any meaningful comparison can be made. In any case the matching of WSSV virus DNA will only provide a match to the origin of the virus but will not confirm the pathway of introduction of the virus.

Pathway 2: the virus was introduced via imported aquatic feed or feed supplements

Investigation

Assessment of prawn feed, probiotics or other additives

Investigators conducted an inventory of a range of prawn feeds and associated products that were used at the infected farms. Nine potential inputs used in the infected prawn farms were identified, which could be the source of the infection. These are:

1) water
2) post-larvae (discussed in pathway 3)
3) feed
4) fertiliser
5) dye
6) probiotics
7) lime
8) molasses
9) In addition, WSSV may have been introduced to the farms through the use of equipment or spread between them by the actions of crabs or birds.

When the results of the interviews with the various farm owners/managers were collated, none of the products were used consistently across all infected premises.

Additionally, some products were used on both infected and uninfected premises. There are another 19 prawn farms located in Queensland and New South Wales and all of the various products listed above are used at a range of these farms as well as other farms across the country.

The investigation also considered the illegal importation of prawn feeds and other production inputs. Previous investigations conducted by the department have uncovered hatchery feed products being illegally imported into Australia. There has been no evidence of this activity to date on the Logan River farms; however, investigations are ongoing.

Assessment

The lime, molasses, dye and fertiliser are not considered the potential source of the infection. Lime because it is routinely used to kill WSSV and molasses as it is extracted from sugar cane and the extraction process involves boiling, which would kill WSSV. The dye used is a vegetable extract and the fertiliser is sodium nitrate.

Pelletised (graded) feed is commonly fed to prawns in the grow-out ponds and probiotics are also used to assist in the management of pathogens in aquaculture facilities.

Stockfeed used on the farms was collected and tested for the presence of WSSV. Results from AAHL showed that WSSV DNA was found in a fish meal ingredient of the prawn feed pellets produced by one of the feed suppliers. Further testing by AAHL indicated that the WSSV DNA

present in the feed was fragmented, which was expected because the manufacturing process for feed involves heat treatment and extrusion (and hence would break up viral DNA into fragments), which would negate the viability of any WSSV that may have been present. Furthermore, feeds are often left for long periods at ambient temperatures, reducing the likelihood of WSSV being viable in the feed. It is advisable that feed intended for use on prawn farms does not contain crustacean meal nor WSSV DNA. The presence of WSSV DNA, though unviable, indicates a possible contamination or substitution issue during the manufacturing, storage or transport process. Given the significant consequences, caution should be adopted to avoid an over reliance on one main risk control measure. Variations in processing conditions or post-production contamination after heat treatment can occur in feed mills. Quality assurance systems that extend to source ingredients could be used to address these issues and provide greater assurances.

The use of feed, additives, probiotics and bio remedial agents if not sufficiently treated, and appropriate stored and transported have been the cause of a number of animal disease outbreaks across the globe. Representatives from feed companies in WSSV affected countries have visited some of the Logan River farms periodically. Legally imported feedstuffs, feed additives, probiotics and bio remedial agents are assessed, treated and regulated to minimise the risk associated with these products. However, the illegal transport and use of these products has been known to occur and cannot be ruled out. This is because samples and small quantities of products can be easily moved between countries and it can be difficult for regulatory authorities to detect. Previous investigations conducted by the department uncovered hatchery feed products being illegally imported into Australia. The companies responsible were prosecuted. Illegally imported feed represents a high risk pathway for WSSV and cannot be ruled out as a possible pathway for the Logan River area outbreak.

Pathway 3: the virus was introduced through diseased broodstock or their progeny

Investigation

Assessment of broodstock and associated supply chains

Broodstock or progeny was also identified as an input used in the infected prawn farms. The post-larvae used on the seven infected farms were produced by Australian hatcheries.

Broodstock used by one of the hatcheries were sourced from wild-caught stock sourced from the northern prawn fishery waters. A total of 10 per cent of these wild-caught prawns provided to the hatcheries are tested for WSSV. No positive detections for WSSV among wild-caught broodstock were made in 2016 and this has also been the case in years previous.

All hatchery operations are epidemiologically linked to the local environment and have limited suitable biosecurity controls in place to prevent the entry, exposure and spread of disease. Other seafood suppliers to the Australian market catch prawns in the same areas as the wild broodstock. These prawns are sent to Vietnam for peeling and returned to Australia for sale. All prawn consignments are subject to testing at the border on re-entry for WSSV and yellow-head virus and have never tested positive.

Broodstock at hatcheries are fed a varied conditioning diet that includes locally caught or bred polychaete worms, which are capable of carrying viable WSSV. Polychaete worms were used on

some of the Logan river farms as well as other Australian farms. Samples were sent for analysis at AAHL and returned negative results.

Assessment

Broodstock and PL's are a well-known source of infection and spread of prawn related diseases, including WSSV, worldwide. As such, standard international practice is to apply strict biosecurity protocols to broodstock development, distribution, spawning, and PL production.

The Australian tiger prawn farming industry is reliant on wild-caught broodstock. Collection of wild broodstock to produce PL's for domestic grow out purposes is not a recommended industry practice for biosecurity reasons. To mitigate the disease risks that may be associated with wild broodstock some polymerase chain reaction (PCR) testing is performed (10 per cent of broodstock collected from the wild are tested). It must be noted that this is only a screening process, it is not targeted surveillance. Therefore, screening 10 per cent of the collected healthy adult prawns is not statistically suitable for making an inference of the disease status in wild populations. The remaining 90 per cent of collected wild broodstock are not tested and not all of the hatcheries inspected kept broodstock following spawning, nor do they test or keep samples of the post-larvae batches produced and distributed for grow out.

Reliance on a 10 per cent screening process using PCR may also result in false negative results as some apparently healthy broodstock may be sub-clinically infected with WSSV and testing may not be sensitive enough (or sampled correctly) to detect sub-clinical infection. It is because of these disease risks associated with wild broodstock that standard modern industry practice strictly controls the domestic production of specific pathogen free (SPF) broodstock within a disease-free compartment.

The hatcheries that supplied post-larvae to the infected prawn farms also supplied post-larvae to multiple other prawn farms, which are not infected. All farms outside the biosecurity zone in the Logan River area that received PLs remain uninfected. This suggests that the post-larvae are not the source of infection although it is unknown as yet whether multiple production batches of post-larvae were produced by each hatchery and if the various farms supplied received different production batches, which may allow for some batches to have been infected and others not due to different broodstock, feed or other inputs varying between production batches. However, broodstock and post-larvae represent the most direct pathway for entry, exposure, vertical transmission of disease, establishment and spread of disease, and cannot be discounted as the original source of infection and subsequent re-infection (and re-introduction) in farms and local wild prawn populations. If WSSV is present in the Logan River environment, there were no biosecurity controls in place to prevent exposure and infection of broodstock to disease from polychaetes capable of carrying viable virus.

Pathway 4: the virus was introduced via a human element including the importation of associated equipment

Investigation

The investigation enquired into the potential for the virus to have been introduced by contaminated equipment or direct human intervention. Searches of departmental records for

imports of used aquaculture equipment or hardware imported by the farms in 2016 did not reveal any activity relevant to the investigation.

The investigation found that on most farms, on-farm biosecurity for movement control of people and equipment was below international best practice. On some farms it was non-existent, and no evidence could be collected that demonstrated visitation or biosecurity measures. On enquiry, farm staff confirmed that some equipment is shared between farms, for example, prawns from other farms are cooked on their premises to share processing equipment. Farm staff also confirmed that their farms are visited by peripheral industry representatives including feed manufacturers, equipment salesmen, production consultants and various sales representatives from Australia and overseas.

Some farms hosted a visit by two foreign visitors (sales representatives) on 25 November 2016. This visit occurred three days after the first signs of the disease presented at the first infected farm and is not considered significant to the investigation however enquires are ongoing concerning this element of the investigation. Nonetheless, it was noted that previous visits to these farms had occurred and some of the farms were known to regularly receive international visitors from countries with endemic WSSV.

Assessment

There is no evidence that the virus was introduced by contaminated equipment used on farms or through direct human involvement. While personnel and equipment are low likelihood pathways for introduction because WSSV is unlikely to remain viable on dry equipment or clothing, some of the infected prawn farms regularly received visitors onto their properties who were associated with the prawn industry from countries where WSSV is considered endemic. These visitors may have been exposed to WSSV in these other countries given their involvement in the industry and may have carried equipment or samples of feedstuffs, additives, probiotics or bio remedial agents for use sometime in the future. The timing of these visits does not have to coincide with the outbreak given these products may not have been used immediately.

Pathway 5: WSSV was present in Australia but had not been detected previously

Investigation

Australia was considered free of WSSV disease prior to the Logan River area outbreak in December 2016. Australia's freedom from WSSV prior to the outbreak has met the requirements of the World Organisation for Animal Health Aquatic Animal Health Code and includes evidence from multiple sources such as: absence of clinical disease on farms (which are epidemiologically connected to adjacent water ways), passive surveillance on farms, testing of wild-caught broodstock, and targeted surveys of wild-caught prawns.

Although Australia has been considered free from WSSV, it is possible that the virus has been present in some wild crustacean populations at very low levels but remained undetected.

WSSV is found in Asian waters and was the cause of the first known outbreaks of the disease in the early 1990s. Subsequent scientific studies have shown that identifiable genotypes of WSSV occur in different geographic locations with different genotypes identified from Thailand, China and Taiwan (Marks et al. 2003).

A more recent outbreak of WSD in Saudi Arabia was found to be caused by a local genotype of WSSV that was distinguishable from East Asian genotypes (Tang et al. 2013). Further studies have identified novel genotypes of WSSV in Madagascar, Mozambique and Saudi Arabia (Tang, Le Groumellec & Lightner 2013). It was concluded that "WSSV detected in these three countries probably evolved in this region".

Assessment

The research currently underway to compare WSSV genotypes may provide evidence to indicate the origin of the virus involved in the outbreak. Until this research has been completed it is not possible to make any conclusions on the origins of the genotypes involved and the period of time that they may have been present in Australia.

Additional information acquired considered relevant to the outbreak of WSSV in the Logan River area

Environmental and biosecurity factors

Effective on-farm biosecurity practices and management are essential in reducing the risk of the introduction of pests and diseases. The production and biosecurity practices of each infected premises were observed, highlighting not only the differences across the seven infected premises but also the standard exhibited on the Logan River properties compared with the farming and biosecurity techniques recommended for use in modern prawn farming operations. There were few biosecurity infrastructure and/or practices in place capable of preventing the disease transmission (apart from some water filtering, pond fallowing and probiotic use), which is in stark contrast to modern-day farming techniques and the biosecurity practices that are put in place to prevent disease outbreak.

Crab mitigation

The infected farms were constructed and operated using a range of different technologies, from simplistic to quite advanced. Some Logan river farms are basic and undeveloped. It was also observed that some farms included rocks and broken-up cement blocks around the edges of the ponds to prevent erosion. Rocky ponds offer a suitable permanent habitat for small crab populations, which are known to harbour WSSV and the farm sites visited all had large populations of small brown crabs. Field staff captured over 50 crabs by hand in a short period of time at one farm. Other Logan river farms have plastic lined banks and one farm, that has earth banks but no rocks, have much smaller crab populations but some crabs are still present. The manager of this farm stated that the crab population had decreased substantially since the rocks were removed from their pond banks.

In modern prawn farm operations crab-proof fences are routinely used to exclude land crustaceans from entering the area of the ponds. No crab-proof fences were observed on any of the infected prawn farms, potentially enabling the movement of crabs in and out of the river, between ponds and possibly even between properties.

Bird mitigation

Birds may play a role in the spreading of diseases within and to other nearby properties. Typical strategies implemented to prevent bird predation issues include exclusion, such as netting and

wires, disturbance and dispersal, such as scare guns and dispersing roosts and lethal mitigation campaigns. Some of the infected farms were observed to not have bird mitigation infrastructure or techniques in place and during the course of the investigation, there were observations of birds collecting prawns from infected ponds.

Water filtration

Modern prawn farm operations treat water prior to stocking their ponds with chemicals to kill any wild crustaceans taken into the farm with the water. The farms that do not filter their intake water reported finding 10 – 40 kg of wild greasyback prawns in each pond at harvest. Other farms filter their intake water as it moves from the intake channel into the production ponds. The size of this filter was stated to be "a couple of hundred microns". However, one farm reported finding glass shrimp when they used feeding trays in their ponds, indicating that this filter size is not sufficient to exclude all wild crustaceans. Additionally, farms share processing facilities . The practice of only filtering the water between the inlet channel and the production pond also allows for a population of wild crustaceans to establish and grow in the inlet channel. This provides the opportunity for free virus to move into the production pond each time the ponds are topped up from the inlet channel.

One farm was noted as running a more professional and more modern operation; however, apart from some probiotic use, limited pond lining and fallowing mud bottomed ponds with lime (dry-out and disinfection) there were no biosecurity practices in place that would be suitable to prevent any kind of disease.

Modern prawn farming biosecurity practices

Successful modern prawn farming techniques incorporate strict epidemiological separation of SPF broodstock, spawning and extended post-larval rearing facilities under a compartmentalised system involving quality-managed biosecurity and health management systems.

Grow-out at farm-level incorporates biosecurity measures focusing on prevention. Techniques are dependent on farm design and production strategy and may include:

- exclusion of susceptible species from the farming environment (crab fencing)
- sourcing cleaner intake water
- intake water treatment (chlorination)
- use of crustacides
- water filtering to <200 micron
- pond lining and yearly cleaning
- bird mitigation strategies
- strict on-farm movement control (for animals, staff, equipment, feed, etc.)
- frequent disease sampling and surveillance
- staff training programme
- regulation of minimum biosecurity standards

- reducing water exchange requirements
- use of probiotics
- lower stocking densities
- increasing aeration
- avoid stocking in cold weather
- extending post-larvae growth in greenhouses prior to stocking for grow-out.

Poor on-farm biosecurity measures used by some of the infected premises combined with outdated production methods may have played a role in the WSSV outbreak or in the spread of the disease from the originally infected premises. International prawn aquaculture expert Mr Francois Brenta who visited the affected farms and prawn farms in Northern Queensland during March 2017 recommended that Australian prawn farmers needed to focus on better on-farm biosecurity and breeding programs for broodstock to ensure disease risks were managed to a minimum level.

The 2009 IRA WSSV Impact Assessment (pp117) paraphrases the AQUAVETPLAN Disease Strategy for White Spot Disease and states that one of the strategic options that could be employed to prevent a disease incursion on farms is for prawn farms to include hygiene and biosecurity measures aimed at mitigating the on-farm effects of WSD (Biosecurity Australia 2009). While this is true for WSD, it is also standard preventative biosecurity practice for any prawn disease and has been incorporated in the design and operation of prawn farms around the world where WSD and other devastating prawn diseases are common.

Conclusion

The assessments within this report regarding the plausibility of each pathway causing the WSSV outbreak in the Logan River area reflect the knowledge and information available to date to the Department of Agriculture and Water Resources. There are ongoing investigations into the WSSV outbreak being conducted by both the department and other entities, including Biosecurity Queensland, which may at a later date provide further clarification as to the likely pathway of WSSV. As it currently stands, the department has not been able to determine the origin of the viral outbreak and a number of plausible pathways exist.

Note:

This report represents the information known to the department at the time of publication. Inquiries are currently ongoing. At the time of publication the following information was still outstanding:

- the genotype of the virus detected in the Logan River area – this work is incomplete and it is likely to take some time before any conclusions can be drawn
- interviews with foreign nationals who visited on 25 November 2016
- investigations concerning allegations received by the department in early May 2017.

Glossary

AAHL	Australian Animal Health Laboratory
AqCCEAD	Aquatic Consultative Committee on Emergency Animal Disease
ARP	at-risk premises
EMAI	Elizabeth Macarthur Agricultural Institute
IRA	Import risk analysis
PCR	polymerase chain reaction
PL	post-larvae
SPF	specific pathogen free
WSD	white spot disease
WSSV	white spot syndrome virus

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