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Paula Reynolds is an aquatic pathologist. Part of her working day is spent carrying out pathology for the koi industry and hobbyists. However, research is Paula's main occupation and she admits to enjoying the painstakingly detailed work that ultimately reveals so much new information.

ISRAELI KOI

...and the battle
against KHV

Paula takes a look at the science that underlies the koi production at MadanKoi – Israel's largest farm at Maagan Michael...

The amazing MadanKoi Farm at Maagan Michael.

Israel has the perfect climate for breeding and rearing fish, so it's not surprising that the country has a long history of producing Sea Bass and Tilapia for human consumption. Breeding koi was a natural progression and many farms have been involved with koi for around 20 years. Nowadays more varieties are produced and the quality of the koi has greatly improved.

Companies that were once well known names in the UK, such as Mag, have now ceased to operate as the four koi producing farms in Israel became independent in 2011.

My Guide

I am lucky to have Ofer Ashoulin as my guide to the koi production methods at Maagan Michael. This is the largest and most aqua-culturally diverse farm in Israel

and one of the country's two major koi producers. It is located between the southern side of Mount Carmel and the Mediterranean Sea at the foothills of the town of Zichron Ya'akov.

The farm is operated by the 'Dag-On' company, although their koi are sold under the brand name 'MadanKoi'.

Ofer's task is to ensure that the highest possible standards are applied at every stage of production so that the koi they export are healthy. Special conditions prevail as the koi are vaccinated against Koi Herpesvirus (KHV), a process that requires very strict protocols and supervision.



What is Koi Herpesvirus?

For readers not familiar with Koi Herpesvirus (KHV) it is a serious viral disease currently notifiable in the UK. The signs of infection can vary significantly depending on how the disease presents, but commonly koi become lethargic, lose their appetite and develop heavy mucus which is shed until the skin feels dry. The eyes can become sunken and changes can occur to gill tissue. However, many such signs occur during other health problems and alone they cannot be regarded as a diagnosis of KHV.

There are tests to confirm an outbreak of KHV – currently a polymerase chain reaction (PCR) test is the main diagnostic aid. Other tests such, as the ELISA, are applied when looking for carriers of the virus. It is possible that a carrier can live in a pond for years with no evidence that it carries the virus. The incubatory criteria required for an outbreak of KHV may simply not have coincided to trigger the virus previously.

New koi are not always the culprit although it is possible to introduce an infected fish from a non biosecure source. Claims that KHV can be cured with various chemicals introduced to the pond are inaccurate. Injections of drugs used to treat human herpes viruses will also fail. Most claims at a 'cure' are made by those who fail to understand the biology of the disease and do not take into account that koi can make a natural recovery.

Survivors of KHV can pass the virus on to other naive koi, although the carrier state is the subject of ongoing study.

Facts and fiction

It is a fact that in the early 1990s the UK had a few cases of what we knew was a viral disease, although it was not known as KHV at that time. Subsequent tests on preserved samples using technology not available back then have proven these early outbreaks were indeed KHV, but the source was unknown.

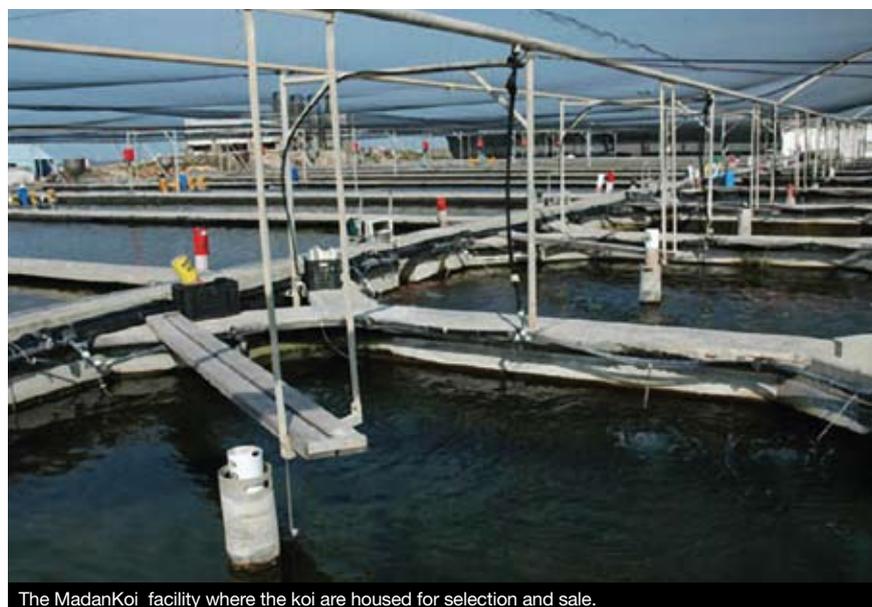
By 1996 there were outbreaks in newly imported fish and, at that time, Israeli koi were implicated as the possible carriers of this new virus. The fact that the virus did not breakout within an identical time frame in all locations led to great confusion, when in fact the incubation criteria for outbreaks had not been met due to climate variations. However, in 1998 there were many cases in the UK and Ofer confirmed that this was the year in which Israel experienced KHV for the first time.

Whilst there are hypotheses as to the origins of KHV, they are speculative rather than factual. It is likely that, given the high incidence of herpes viruses in many fish species, an early form of the disease made what is termed a vertical shift from an unknown host species into koi.

A virus needs to be able to reproduce before it can survive in a new species. Once it has achieved this it is then a bonus for the spread of that virus if its chosen host is a popular fish that can travel freely around the world! Koi were therefore a prime target.

The history

Ofer and I are well aware that when KHV became a reality around the world there



The MadanKoi facility where the koi are housed for selection and sale.



The rearing ponds for MadanKoi.



were no measures in place to deal with the disease. It rapidly spread in the same way that certain viruses can do in the human population.

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There is no doubt that the virus did at one time threaten koi production in many countries. Brood stocks are vital to any farming operation and certain bloodlines can be expensive or even impossible to replace.

I recall taking part in several meetings with representatives from Israel and many other countries to discuss the virus when it initially emerged. It was clear that the

containment of the disease was the responsibility of the koi industry. It was impossible to standardise methods so every farm had to improve their biosecurity measures and find their own solutions for keeping the disease out of their koi production.

A difficult time

Attempts were made to control the disease with early vaccines in Israel which, with hindsight, perpetuated the disease. As a result hobbyists with Israeli koi at that time were concerned that they could be carriers of the virus.

Ofer is very honest and admits mistakes were made when KHV first emerged. However, we are both in agreement that this is equally true of the reactions in most koi producing farms around the world. It was



Israel though that recognised the need for a completely new approach to the disease in advance of many other koi producers.

KOVAX, a company with the capacity to introduce state of the art technology into the situation, then created the KV3 vaccine which is now used in the koi immunisation program.

“There is now a total commitment to safer koi production by MadanKoi.”

Koi dealers and hobbyists around the world can be assured that greater understanding of the biology of KHV has gone into overcoming the disease in Israel. There is now a total commitment to safer koi production by MadanKoi.

KV3 vaccination process

- Most of the MadanKoi are vaccinated at ten grams in weight when they are no less than three months old.
- KV3 is an immersion vaccine. During the bath, and for the subsequent 26 days, the koi must be kept in a virus-free environment.
- A biomass of 200 kilo of koi is placed in a bath of 1,000 litres of water at 22-23°C for 45 minutes.
- Then the koi are held for five days at the permissive water temperature of 22-24°C.
- The koi are then kept for three weeks at a water temperature above 29°C. This third stage can be taken at any temperature above 22°C as long as there is no virus in

the environment. The Magaan Michael mud ponds are 29-30°C and are practically virus free.

- A month after immersion a sample of koi from each pond is brought to the wet laboratory and observed for three weeks in which the koi undergo a challenge with wild type KHV.
- This is carried out through cohabitation with sick fish in a well calibrated protocol.
- Any RPS (survival rate) result below 85% requires checking again during winter.
- Batches that do not meet this figure will be given a booster, but the need for this rare.
- The minimum RPS (survival rate) for sale is 95%.

Production levels

Dag-On has a team of 90 employees in total and the company produce four million five-gram koi a year. Out of these 600,000 are sorted and vaccinated. Eventually 400,000 koi measuring four to 24 inches are sold. Ofer is certain that this level of popularity demonstrates their safety.

At Maagan there is also an isolated biosecure facility that produces naïve koi. This means they have never been exposed to KHV or vaccinated. There are plans to extend this to support the growing demand for small koi.

Failure rates

There is no possibility of a 100% success rate with any vaccine in any animal species, and I asked Ofer what MadanKoi see as

their failure rate. Only 1% of all koi are not actually immunised by the immersion delivery method they use. There are various factors as to why this happens but some fish simply fail to take up sufficient vaccine.

“Ofer is satisfied that MadanKoi are very close to the ideal when it comes to vaccine administration.”

They may therefore be unable to survive if and when they are ever exposed to KHV.

The management protocols are designed to ensure that from 1,000 koi vaccinated with the KV3 vaccine that can be purchased by a hobbyist, only one koi may not be immunised and, naturally, this koi poses no risk to any other koi. Ofer is satisfied that MadanKoi are very close to the ideal when it comes to vaccine administration.

Success levels

I wondered if Ofer had experience of different vaccine formulations as I had taken part in trials of vaccines in my own facilities in the UK. My team also assessed the various techniques other than immersion for delivering vaccines. Some methods create higher failure rates, although the type of vaccine can limit the choice of delivery method.

It was obvious that Ofer is satisfied with the success of KV3 by immersion, although he has a keen interest in other technologies. I asked if his confidence in the KV3 vaccine was such that he would support its universal adoption if the legal loopholes for the vaccine could be overcome. His response was that the combination of aquatic environment and deadly virus has no solution other than an effective vaccine, and KV3 is available now.

There are human health considerations when considering any mass immunisation program as many Carp species are part of the human diet in certain countries. Therefore it is not possible to standardise the use of vaccines without controls in place.

“...the USA will soon register and market the KV3 vaccine.”

The KV3 vaccine had to be legalised for use in koi in Israel but it is not yet legal in any other country at the moment. However the British government took the decision to allow the import of vaccinated koi into the



UK, and the USA will soon register and market the KV3 vaccine.

What I advise

I advise clients of my laboratory to buy vaccinated koi if they have had an outbreak of any strain of KHV. This is a positive way to restock a pond that has lost a lot of koi to KHV, and it means that the surviving koi that have become pets do not have to be euthanased.

Ofer and I were in complete agreement that this is a major role for MadanKoi. It can be a sad experience for many koi keepers to have only a few survivors following an outbreak of KHV. To be able to introduce new koi to their ponds again can make all the difference to the hobby.

Ofer is aware that over the last few years I have introduced KV3 vaccinated koi into my own facilities in the UK. They are now living alongside koi from Japan and many other countries, as well as UK bred koi. There have been no health issues at all with any of the vaccinated koi or their companions.

The future

A virus has many aspects that have to be considered beyond the actual disease itself. Epidemiology is the science that looks at the statistics, patterns and wider issues any disease creates. The number of outbreaks of KHV in the UK has decreased, which suggests that changes have occurred in the



biology of the virus and also that control measures around the world are taking effect. Defra giving KHV notifiable disease status in the UK has been a contributing factor.

Cefas, an agency of Defra, in layman's terms are the 'fish police'. I will be forgiven for using this term as it is their duty to ask lots of questions, look at import documents and track down the sources of disease and illegal imports of fish.

I asked Ofer if this downward trend in outbreaks continued, did he think mass immunisation may ever be necessary. His reply surprised me when he declined to comment due to the fact they have no outbreaks of KHV in Maagan Michael. To me that says a great deal about Ofer and MadanKoi. The team do their job without speculating on what is going on elsewhere. They know that viruses are subject to change, and this makes them not only hard to study, but impossible to predict.

The challenge

I explained to Ofer that my work keeps me in contact with dealers and hobbyists and makes me aware of their concerns about the whole subject of vaccination in koi. The number one issue is the fact that vaccines have been known to perpetuate the diseases they are intended to prevent. It is impossible for hobbyists to appreciate how different the basis of the KV3 vaccine is to those that preceded it.

The exposure of the vaccinated koi to live virus to challenge the success of the vaccination process raises concern that the koi, although unable to contract the disease, could act as a 'reservoir' for the live virus.

Ofer explained that a 50-fish sample from each pond is exposed on purpose to the wild virus. The rest of the koi have the potential to encounter the virus in earth ponds but it is rare for them to do so. As a koi producer Ofer favours a natural exposure as it does nothing to the well vaccinated fish and clears out those that do not acquire immunity. In reality the presence of KHV in the farm is hard to detect.

I discussed with Ofer that, as a scientist, I am able to appreciate the progress that has been made and I have the experience of having vaccinated koi to study. However, koi keepers and dealers in the UK need greater reassurance about safety – not just regarding the KV3 vaccine, but the whole vaccination process. I hoped he was able to give them confidence in MadanKoi.



Ofer's response was that properly vaccinated koi are able to eliminate wild KHV upon exposure and are not carriers or reservoirs of live virus under any conditions and they can safely live in any koi pond, although in a virus free environment the immunity of a vaccinated fish decreases in time.

And finally

We have to accept that viruses exist in nature and can cause variable levels of harm to all living things. Koi will never be an exception. We cannot become complacent about viral disease in any pet animal and it's important to remember that KHV is not the only virus that can pose a risk to koi.

The only way to overcome the natural concerns of dealers and hobbyists regarding any disease that puts a pond of healthy koi at risk is with greater insight not

"...it's important to remember that KHV is not the only virus that can pose a risk to koi."

just in respect of the disease itself, but the wider issues that the disease creates – how it is accurately diagnosed, if it can be treated and cured, or if eradication by immunisation is the only way forward. This then allows everyone involved with koi to make informed decisions in respect of their own fish.

I am grateful to Dag-On for allowing for this article to be published. My thanks to Ofer for his expertise, openness, honesty and his commitment to the highest possible standards in koi production.