OPERATION NEST EGG

Incubation and chick rearing best practice protocols

Version 3 (Edited 2024)

Save the kiwi

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1. Introduction

The purpose of this document is to outline the current best-practice knowledge, protocols, and training procedures available for Brown kiwi as part of the Save the Kiwi Operation Nest Egg™ (ONE) programme. It draws together the most up-to-date information and current best practices from the ONE programme in one place, and makes this resource available to all current, and prospective, ONE captive rearing centres.

While this document will focus primarily on Brown kiwi minimum standards, there will be some key points within this document where different species, mainly Rowi, Haast Tokoeka and Great Spotted Kiwi, will be mentioned as the husbandry systems and protocols used vary slightly from that used with Brown kiwi.

As in the Brown Kiwi (Apteryx mantelli) Husbandry Manual (Fraser and Johnson, [Barlow updated] 2015), this manual sets out clear minimum standards for key aspects of the ONE programme that must be met by all captive rearing centres involved in the programme. It is acknowledged that there will always be some variation in practices at different captive rearing centres, and it is not the purpose of this document to eliminate all this variation. However, as with the Brown Kiwi Husbandry Manual, the minimum standards included here provide a degree of quality assurance that all ONE captive rearing centres are providing a suitable and appropriate level of husbandry.

This ONE Best Practice Manual also contains two key performance standards that captive rearing centres are encouraged to aim for. These relate to viable egg hatching success and chick survival rates and should be readily obtainable if the minimum standards are applied.

This document contains information primarily for the husbandry of Brown kiwi eggs and chicks as part of the ONE programme but will include variances, as stated, for Rowi and Haast kiwi in specific chapters. Consequently, it will not duplicate the material contained in other kiwi husbandry and care documents but should be used in conjunction with them.

These documents are available free of charge from the Department of Conservation (www.doc.govt.nz) and should be consulted as necessary. They include:

- Kiwi Recovery Plan: 2018-2028 (Germano et al., 2018)
- Kiwi Best Practice Manual (Robertson and Colbourne, 2003 [updated 2024])
- Brown Kiwi (Apteryx mantelli) Husbandry Manual (Fraser and Johnson, 2009 [updated Barlow and Travers, 2015] [updated Jenkinson and Bean 2024])
- Kiwi First Aid and Veterinary Care (Morgan, 2008 [update in progress])
- Kiwi Captive Management Plan (Barlow, 2018)

Due to issues associated with intellectual property rights, the Save the Kiwi ONE Kiwi Egg Candling Workshop Study Guide (Bassett, 2009) is only available to those persons who have attended and completed the Kiwi Egg Candling Workshop. This document is not currently able to be downloaded electronically.

This ONE Best Practice Manual will be reviewed every five years, and any new or improved techniques will be added, as necessary.

2. The Origins of Operation Nest Egg – ONE

Operation Nest Egg™ - formally the BNZ Save the Kiwi Operation Nest Egg™ - and often referred to as ONE, is a powerful tool used to quickly build up kiwi numbers, particularly vulnerable kiwi populations in small sites. Kiwi eggs and chicks are removed from the wild and hatched and/or raised in captivity until big enough to fend for themselves – usually when they weigh around 1000 grams. They are then returned to the wild.

An ONE bird has a 65% chance of surviving to adulthood – compared to just 5% for wild-hatched and raised chicks.

It is used on all kiwi species except the Little Spotted kiwi and only minimally on Great Spotted kiwi.

The idea for Save the Kiwi, Operation Nest Egg™ was developed in 1994 when researchers noticed that almost all kiwi chicks were killed by stoats, but adult kiwi were not.

With funding from Save the Kiwi (then BNZ Save the Kiwi Trust), a pilot was run that adapted the 'operation nest egg' technique specifically for kiwi.

The skills for collecting, transporting, and incubating kiwi eggs, then keeping young chicks alive in captivity, were honed on brown kiwi. With only 5% of wild-hatched chicks surviving to adulthood, there was nothing much to lose.

It worked – ONE™ has been incredibly good for quickly growing kiwi populations near the brink of extinction, such as the critically endangered Rowi and Haast tokoeka. It has also been very effective in helping establish new populations.

Since 1995, Operation Nest Egg has been used every breeding season, largely in the most vulnerable kiwi populations, buying researchers the time to find solutions to the problems facing kiwi. The aim is to develop long-term cost-effective and sustainable ways to keep large areas of forest free of predators. There may come a time when ONE will no longer be needed as a management tool, although its power as an advocacy tool - giving people an opportunity to get close to kiwi - will remain immensely valuable.

Save the Kiwi has continued to sponsor kiwi recovery work since funding the initial Operation Nest Egg pilot in 1991. BNZ Save the Kiwi Trust was formed in 2002, rebranded as Save the Kiwi in 2021, an independent trust that is the only national charity dedicated to kiwi conservation, and over the years has granted many millions of dollars to kiwi protection projects on the ground. The Trust stands alongside the facilities, people and projects that have developed Operation Nest Egg to be the robust management tool it is today and is proud to support the work by funding training workshops, incubation facilities and projects on the ground.

More information about Operation Nest Egg can be found at **www.savethekiwi.nz**

3. Permits, Training and Kiwi Accredited Handler Reports

All facilities that undertake care of kiwi, either as part of the captive programme, for rehabilitation or as part of the Operation Nest Egg programme are required to obtain a permit from the Department of Conservation. This falls under the Welfare Act of 1953. For further information on permits refer to the Kiwi Best Practice Manual, (Robertson and Colbourne 2020) or contact the department of conservation at:
www.doc.govt.nz/get-involved/apply-for-permits/interacting-with-wildlife/

With the increased awareness of the need for excellent animal welfare requirements in the captive management of native species there is also a need for a structured and consistent approach in training of staff hired to care for these animals. While it is acknowledged that the staff at most captive institutes have some competencies, they will often need some upskilling in others.

To assist with the training of staff a series of training modules have been developed to cover all aspects of skills required not only for ONE, egg handling, incubation and hatching but for the captive management and husbandry of kiwi chicks, juvenile and adults too. These modules align with the formal accreditation system for handling kiwi that the Department of Conservation (DOC) have introduced, known at the Kiwi Accredited Handler report (KAH). These training modules are available for all staff who work with kiwi and should be incorporated into the onsite training schedules. A comprehensive list of the modules available can be seen below.

The Kiwi Recovery Group maintains a database of all handlers that have been registered as competent to carry out certain tasks. To be added to the register and achieve accreditation the applicant must show that they have read the relevant sections of the appropriate best practice manuals, but they also need to supply a letter of recommendation from an accredited trainer/s for the particular task(s) being registered for.

Each task (listed below) requires a specific level of training to become accredited. It usually consists of observing a trainer demonstrating the set task up to 5 times. The trainee then must demonstrate their ability to replicate that same skill in front of a trainer five times (known as "See 5, Do 5"). If the accredited trainer is confident with the trainees level of competence, they can then write a letter of recommendation to the Technical Administrator for the New Zealand Bird Banding Scheme (NZNBBS) & Kiwi Accredited Handlers Database (KAH), Department of Conservation, (kiwihandler@doc.govt.nz), and the trainee will be accredited for that task.

This training is dependent on the individuals ability to complete the set task confidently and competently while achieving the best welfare outcomes for the birds held in captivity. It is acknowledged that some individuals have differing rates of learning and therefore meeting the minimum threshold is not a guarantee of certification. The trainee might require more training than the designated five times to be signed off, this is at the discretion of the trainer.

The list of tasks that a staff member can be accredited for is very comprehensive and in certain circumstances can be difficult to achieve the See 5, Do 5, for all staff. To assist with this, some training videos have also been developed and can be accessed at: https://www.youtube.com/playlist?list=PL-N-bRAzQiU7qJPQ3Nz9poYI9isIUJiNE

If you can demonstrate you have watched the training videos three times, viewed that task being demonstrated by a trainer twice and then been observed completing the task accurately by the trainer five times (Video x 3/See x 2, Do 5). You can also be signed off as accredited.

Each year, everyone on the register must let Kiwi Recovery Group (DOC) know the approximate number of kiwi they have handled under each task description to maintain their accreditation. All communications about the KAH and training requirements need to be directed to kiwihandler@doc.govt.nz

Refreshers are required if the accredited handlers have not carried out the endorsed task(s) for a few years. To retain accredited status, you need to have done one of each competency you are registered for within a two-year period. If you have not done any of the competencies within a three-year period, then you will need a refresher under the supervision of an accredited trainer.

Experienced handlers who have performed various tasks the stipulated minimum number of times can also apply to the Kiwi Recovery Group to become endorsed as an accredited trainer for tasks. The required number of times a task must be completed is also found in the table below.

Training Module Number	Task Description	To be Accredited you need to have seen and done:	# of tasks completed to become a trainer
Module 1	Extract catch release (chick)	Video 3/S2 or See 5, Do 5	50
	Extract catch release (juv/adult)	V3/S2 or S5, D5	50
Module 2	Handling chick	V3/S2 or S5, D5	50
	Handing juv/adult	V3/S2 or S5, D5	50
Module 2	Upright hold for dosing	S5, D5	50
Module 3	Standard chick husbandry	S5, D5	50
	Advanced chick husbandry	S5, D5	50
	Assist feeding chicks	S5, D5	30
Module 4	Standard juv/adult husbandry	S5, D5	50
	Advanced juv/adult husbandry	S5, D5	50
	Assist feeding juv/adults	S5, D5	30
Module 5	Hold for blood	S5, D5	30
	Hold for cloacal	S5, D5	30
	Hold for transponder	V3/S2 or S5, D5	30
Module 6	Oral tube dosing	S5, D5	10 kiwi/40 other birds
Module 7	Take blood	S5, D5	10 kiwi/40 other birds
	Take cloacal	V3/S2 or S5, D5	30
	Insert transponder	V3/S2 or S5, D5	30
Module 8	Captive egg lifts	V3/S2 or S5, D5	10
	Captive egg transportation	V3/S2 or S5, D5	10
Module 9	Egg washing	V3/S2 or S5, D5	10
	Treat cracked eggs	V3/S2 or S5, D5*	10
Module 10	Egg candling	V3/S2 or S5, D5	50
	Egg incubation (min. standard)	S5, D5	50
Module 11	Hatching (min. standards)	S5, D5	50
Module 12	Egg complications	V3/S2 or S5, D5	15
	IM treatment	Vet advice	
	Sub-cut treatment	Vet advice	

Minimum Standard 1.
Handling kiwi eggs or chicks

a) Kiwi eggs, chicks and juvenile's must only be handled by people trained in the appropriate manner and are registered in the Department of Conservation data base as a Kiwi Accredited Handler.

Table 1. Training Modules Available to Achieve Kiwi Accredited Handling Certification

4 Kiwi Egg Lifting and Transportation from the Field

The first step in the artificial incubation and rearing of ONE eggs and chicks is the collection of eggs and their safe transportation to the captive rearing centre. It is assumed here that all field staff and volunteers who are involved in monitoring and transporting kiwi will be familiar with the Kiwi Best Practice Manual (Robertson and Colbourne, 2003 [updated 2024]), will be accredited to lift eggs, and that some staff in each project have attended either the Save the Kiwi Operation Nest Egg™ Best Practice Field Practitioners Course or the Best Practice Ex-Situ Practitioners Course and are able to determine the age and viability of kiwi eggs. The main information regarding egg (and on occasion young chick) removal, and safe transportation, is outlined below.

4.1 Egg Lift Preparation

Good planning, communication and preparation is essential – accidents and mishaps can happen but using best practice along with good communication can mitigate problems. If an accident has occurred, immediately contact the coordinator and the captive rearing facility so that they can be prepared and can cater for any damage in the most appropriate way.

In any given situation if you have found an egg/eggs in a nest and are not prepared for them, the ideal option is to leave the site and return with the correct equipment.

Never carry the eggs out in a backpack!

4.1.1 Equipment List Required for Egg Lift

Part of good planning is ensuring that you have all the right equipment with you and that you are also prepared for the unexpected, e.g., a three-egg clutch or a young chick. Most practitioners have their equipment stored in a plastic snap-lid container. It is preferable not to store your gear in plastic zip-lock bags, they are too noisy, and kiwi can behave adversely to this noise.

- All necessary equipment required to keep you safe while working in the bush. Each project will have a health and safety plan that will list what you need.
- Telemetry gear
- 2 chilly bins (one can stay in the vehicle), that have been adapted for carrying eggs, usually by having prepared foam inserts placed inside. Depending on the size of the chilly bin and the configuration of the inserts, the chilly bins can normally cater for 1 to 2 eggs, (see figures 1 and 2). Make sure the correct direction of travel is marked as an arrow, on the top of the chilly bins.

- In the event there is a third egg, be prepared. Some chilly bins can be formatted to carry 3 egg in an emergency or as an alternative, an empty TR4 carry case can be used. (See figures 3 and 4 for examples). NB whatever method is used the container holding the egg must be carried out by hand to minimise jarring to the egg. Do not place in a backpack.

Figure 1. Single egg transport box (Photo: National Kiwi Hatchery)

Figure 2. Double Egg Carry Box Correct (Photo: The Gallagher Kiwi Burrow)

- Paper towels, or non-slip matting to place between the foam insert and egg.
- Pencil Torch – preferably with a soft sponge contact ring stuck to the lens, this both reduces the risk of accidentally cracking the egg with the torch edge but also forms a seal, directing the light into the egg for more accurate candling.
- Paper work/data systems - including egg transfer sheet and the captive facility's information sheet on driving eggs/chicks for couriers.
- Hand trowel or spade.
- Pruning saw.
- Medical or masking tape.
- Sterilised pads.
- Candling hood (or jacket) for candling under.
- Soft pencil for marking the top of the egg and air cell.
- Flat packed small core flute box in case of an unexpected chick.

Figure 3. Foam strips used to create 3 chambers, for emergency use. The strips can be stored under the main piece of foam. (Photo: Kevin Stokes)

Figure 4. TR4 Receiver carry case used in an emergency. (Photo: National Kiwi Hatchery)

4.1.2 Optional Equipment:

- Flexible mirror
- Gear for processing the adult – new Tx and banding tape, callipers, spring scales etc.
- Catch bag.
- Hot water bottle

4.2 Egg Lifts

Eggs are generally lifted during the day which makes the process safer and easier to manage from the Health and Safety aspect. But in nearly all circumstances this means that the nesting adult will be in the nest and on the eggs, while you are trying to remove them. Which can, on occasion, lead to an egg being damaged by the incubating bird during the egg removal process.

Some projects are still preferring to do an egg lift at night, ensuring the incubating adult has left the nest before attempting to lift the eggs. This means that the adult bird will not be disturbed, but a night lift can be more difficult to organise and manage.

It is also prudent to limit the number of staff that go to an egg lift, three staff are more than capable of lifting and transferring eggs from a nesting site.

- Prior to an egg lift, ensure the captive rearing facility has been notified that eggs will be brought in. Also, that the egg courier/transport is fully teed up and informed of their task, which includes having an up-to-date list of necessary contact details.
- Ensure your planning enables you to get the eggs to the incubation facility within the 12-hour maximum time limit.
- Prepare your chilly bin egg carry box. And make sure you have all the equipment you will need with you.
- Once at the nest ensure the incubating adult is alert and aware of your presence.
- It is better to use bare hands when reaching into the nest – it maintains dexterity and sensitivity when handling the eggs. It also allows your hand to act as a shield over and around the top of the egg if you are reaching under the male. If he does lash out, he is more likely to hit your hand and not the egg.
- Often the male will back away from the eggs. Even so, carefully grasp the egg using your whole hand to cover around the top of the egg, removing them one at a time. Do not rotate the eggs but mark the top of the egg as it comes out of the nest with a very small pencil line (so that you know what way the egg was sitting in the nest).
- Place the first egg immediately into the chilly bin and remove the second egg in the same manner. Always check for a third egg, or egg fragments if only one egg is found.
- In certain situations, if you are not able to reach the eggs you might need to dig some of the entrance out or access the nest via a shaft.

- When all eggs have been collected from the nest, they can then be candled with a pencil torch to determine:
  - position and size of aircell
  - if the aircell is crisp and fixed or fluid/uneven
  - top of the egg (where the air cell is the largest)
  - if the egg is alive or dead
  - if there are any cracks
  - approximate age of egg (this is not essential and just determining very young vs well developed is enough)

If the egg is not the right way up, then gently rotate the egg until it is. You can now mark the true top of the egg (vs position at the top in the nest) and lightly draw in the air cell with pencil. One of the easiest ways to do this is by placing the eggs in the foam in the chilly bin and candle them in this position while drawing on your markings (See figure 5), or by placing them on your lap as seen in Figure 6.

- In the unlikely event that an egg is cracked during removal or found with an existing crack or concave dent in it (rather than convex crack, that indicates it is hatching), handle the egg extra carefully. You do not need to do anything with the cracks at this point. The captive facility will later clean and seal the cracks on site. BUT if there is a hole in the egg or severe cracks with either blood or egg contents leaking out, place the egg in the carry box, hole side up. This is the only instance where you do not worry about the air cell. Cover the hole with a sterile pad held in place with small pieces of masking tape or medical tape. Do not use an excessive amount of tape as it will need to be removed on arrival at the incubation centre when a full repair will be made.
- Ensure the direction of travel of the egg box is correct (see section 4.3.1).
- Take extra time in carrying the eggs out, do not rush. It is surprising how bumping or swinging the box can cause transport damage to the egg membranes. Bend your arm, holding the chilly bin away from your body, as you walk will prevent the bin hitting against your leg. Having a second person to share the load can be good, especially to help with difficult spots on the track. Be careful to place the handle of the chilly bin gently down and not allow it to bang down on the side.
- When driving out to the courier make sure to drive carefully over areas of rough road, ensuring the eggs are positioned correctly in relation to the direction of travel (see section 4.3.1). You should identify potential problem areas on your trip in. You may need to drive very slowly and have the egg box held up by a passenger. If on a quad bike, you may need to walk the eggs over these rough areas.
- When arriving at the courier vehicle, briefly open the lid of the chilly bin and quickly candle to determine that the eggs is still in the correct position and the air cell has not changed during transportation.
- Fill in the egg transfer sheet with information on date, location, sire name, egg code and clutch number. Record all issues that occurred at any time during the egg removal process including an aggressive male, trips, falls and drops, rough terrain, bumpy roads, or accidents. All information will be relevant if there are damaged eggs.
- If the eggs cannot be delivered immediately, please advise the incubation facility for advice.

Figure 5. Egg being candled, while it is resting on the foam padding in the carry box. (Photo Gallagher Kiwi Burrow)

Figure 6. Egg gently resting in a wool beanie, on the lap of the egg lifter. (Photo: Claire Travers)

4.3 Egg and Chick Transportation

Ensuring the eggs are transported as safely and securely as possible is essential in reducing transport damage. The membranes inside the egg shell can be very susceptible to damage, caused by sudden movement e.g., the abrupt stopping or starting of the vehicle, sharp cornering or swerving and driving too quickly over a corrugated road surface. This rapid movement can cause the membrane to tear away from the shell, split or bleed, which, if severe can cause the death of the embryo.

Each incubation facility will have a comprehensive information sheet giving details on how best to courier eggs to the facility, including how the eggs need to be positioned inside the carry box in relation to the direction of travel. It will also include the address of the facility and the contact details of the staff there.

4.3.1 Direction of travel

- The egg carry box needs to be strapped into the car safely to restrict any movement, but it also needs to be level. Most car seats are set at an angle, so newspapers or towels can be used to level off the seat.
- The egg must be placed horizontally in the chilly bin. The length of the egg must lie sideways to the direction of travel when walking with the egg, and when the egg is travelling in the car. It is a good process to check and double check you understand this.
- Mark the top of your egg box with the direction of travel. This will be different for each egg box depending on how the eggs are placed inside (see fig 1 & 2 above).
- The driver should be aware of the weather conditions, the distance to get to the facility, have enough fuel to get there, and travel more slowly than usual, especially on gravel roads.

- They need to take corners more gently and avoid heavy breaking.
- See below, Figure 7 for quick refence for egg direction in relation to travel direction. This graphic is viewed from above.

How to safely transport eggs

- Make sure you position the chilly bin so that the blunt end of the egg(s) do not face the direction of travel - this can cause the contents of the egg to slosh about as you walk/slip or drive and brake:

Direction of travel

- Keep the eggs horizontal in the chilly bin
- Eggs can be strapped into the seal of the vehicle or they can travel in the boot or foot well, but they must be placed securely and not allowed to slide about.

4.3.2 Safe Chick Transportation

How a chick is transported will depend very much on how old the chick is. If the egg is physically hatching out of the egg or the chick still wet from hatching, then the egg/chick will need to be in an egg carry box and it will need an external heat source to ensure it does not get cold/hypothermic. Place a warm water bottle (28°C) in the bottom of the egg carry box, then place suitable padding on top of the warm water bottle for the chick to snuggle up on. If the egg is hatching gently place padding around the egg so it is secure but not restricted. Ensure you are able to keep the chilly bin lid slightly ajar for air flow, a very small gap is all that is necessary.

A young chick that is dry and fluffy can be transferred in an egg box too. Replace the foam with a nonslip material (or fronds) so the chick does not slide around. Again, ensure you are able to keep the chilly bin ajar just slightly for air flow.

An older chick is much more capable of jumping so may need a bigger carry box (corflute carry boxes are ideal) with the lid firmly closed to prevent it escaping. Ensure it has air holes. Be aware – they CAN and will poke their bill out of the airholes in any carry box.

Do NOT lift the lid to check the chick – they CAN and WILL jump.

Figure 7. Chick in a carry box, hatched during transport, credit National Kiwi Hatchery.

4.4 Transportation Damage

Damage causing the aircell membranes to pull away from the shell can occur in various situations during the process of lifting and transporting eggs to an incubation facility.

If eggs arrive at the incubation centre damaged, there is a process that needs to be followed to determine if the damage occurred during transportation, egg lifting or was, as can happen, a natural occurrence. This is so that constant improvements in systems and handling can be implemented to reduce the risk of further damage. Usually, a photo is taken, and the degree of damage recorded. The coordinator will be informed, and further processes implemented to stop further damage from happening again.

5. On Site Hygiene and Health and Safety Management

With any Operation Nest Egg (ONE) kiwi captive rearing facility, there is not only a risk of accidently introducing pathogens into the wild populations and potentially causing a disease outbreak once birds are released. There are also risks of disease outbreaks within the facility when holding a lot of eggs and chicks on site for extended periods of time. This risk can be compounded by many facilities being open to the public as part of the advocacy programme for the species, though there are always areas the general public will not access (back of house).

This continues into all aspects of Health and Safety (H & S) on site with increased risks of exposure to zoonotic diseases as well as the constant hazards that occur while caring for animals in an intensive environment, both inside and outside. Each individual facility will have developed their own standard operating procedures and H & S plan, which should include a comprehensive risk register and evacuation plan. Serious efforts must be made to minimise these risks by ensuring all staff and visitors are aware of any on site H & S requirements and procedures, and that they must follow these processes.

The following procedures are recommended, but more specific details on hygiene and quarantine systems used will be incorporated within the following chapters.

5.1 General Procedures

- Staff and associates should be made aware of the H&S procedures in place to minimise the risk of accidents or the introduction of disease/pathogens to the captive rearing facility, and the threat they may pose to captive and wild kiwi.
- There should be no unauthorised entry to any incubation, brooder, or chick rearing area.
- All staff should change footwear before entering an ONE kiwi area to reduce the risk of transfer of diseases. There should be a clearly marked space for footwear changes and dedicated footwear or overshoes provided.
- All footwear should be cleaned regularly with a Sterigene solution or something similar.
- Staff handling other species of wildlife onsite, are required to mitigate possible disease transfer prior to handling ONE kiwi at the captive rearing facility for example by washing hands, wearing gloves, and wearing clean coveralls.
- Clean clothes are to be worn on site, and people who have been in contact with wild kiwi (i.e., volunteers bringing kiwi eggs or chicks to the captive facility) should remove boots at the door and not have access to any on site areas containing eggs or chicks.

- Hands are to be washed and sanitised regularly while participating in all tasks but particularly when in the brooder area or chick runs. Hands should always be washed and sanitised after handling birds, cleaning brooders, collecting food dishes or cleaning food boxes.
- Gloves (personal protection equipment - PPE) should always be worn for faecal collection for disease screening in order to minimise the risk of staff contracting zoonotic diseases (such as Campylobacter or Salmonella), as well as reducing any spread of disease to other kiwi. After the collection is complete hands should be washed and sanitised.
- All ONE chicks that have been held outside the brooder room i.e., in outdoor pens must be screened for disease prior to the transfer. An example of a standard kiwi quarantine procedure is outlined in these protocols and should be followed. But in certain circumstances extra health checks may be required. All test results must be within normal limits as stated by your vet and on site standard operating procedures.
- All equipment will be sanitised at the commencement of the kiwi breeding season, in particular, all equipment in the incubation and brooder facilities. Equipment must also be cleaned regularly throughout the breeding season. Only essential items should be kept in the incubator and brooder rooms, and only sterilised/autoclaved equipment used for hatching.
- Tools used in kiwi enclosures outside must be cleaned immediately after use and should remain outside and not be brought inside the facility.
- All fruit and vegetables purchased for kiwi food preparation should be of human quality and well washed before use. Optimal storage temperatures should be followed and use by dates should be checked regularly (i.e., cat biscuits, vitamin pre-mix).
- The batch details of all bulk supplies and medical supplies should be recorded on arrival.
- All food items must be held in clean, rodent and insect proof containers.
- A pest management strategy must also be implemented on site to ensure that any unwanted and undesirable pest species are controlled in an appropriate manner.
- Waste should be removed from the facility daily and must be removed from the incubation room immediately.
- Sick birds should be isolated to minimise the contamination of other ONE eggs or birds. It is recommended that facilities have a separate room dedicated to the medical treatment of sick birds.
- If a bird is found to be sick, injured, or dead, follow the procedures laid out in the Kiwi first aid and veterinary care (Morgan 2008) manual.

6. Hygiene in the Egg Arrival, Incubation and Hatch Room Areas

In general, earlier life stages (e.g., eggs and hatching chicks) require higher levels of hygiene and quarantine than later ones (e.g., chicks in outside runs). Therefore, where possible it is preferable to ensure that staff work in a one-way direction through the incubation room, hatch room, brooder room, and then into the outdoor pens.

6.1 General Hygiene Points

One of the prerequisites to ensuring good hygiene at captive rearing centres is to make sure all staff are familiar with the onsite hygiene procedures and that they become an integral part of the daily routine.

- Sterigene 1% solution is recommended as the primary cleaning agent to be used within the captive rearing facilities. Alternatives to Sterigene include diluted bleach solution, Geosil and F10. Chlorhexidine (Microshield) 4% solution can be used for general cleaning, but all residues must be washed off with a freshwater rinse. It is important that all instructions and dilution rates as recommended by the manufacturer are followed.

- Handy Andy is not recommended (kiwi deaths have been attributed to the toxicity of Handy Andy build-up in brooders).
- Hand washing and sanitising facilities should be provided prior to entering each room.
- All cupboards, surfaces walls, floors and ceilings are to be cleaned regularly throughout the season, as per your onsite standard operating procedures.
- All equipment entering the incubation or hatch room must be disinfected with Sterigene prior to entering the room. Ideally any equipment that goes into the rooms should stay in the rooms and not be constantly removed and replaced.

6.2 Incubation Room

- This area must have the strictest hygiene regime with regular cleaning. All floor and work surfaces should be of a non-permeable material to maintain a high state of cleanliness and reduce the establishment of any potential pathogens.
- The incubation room must be completely scrubbed with Sterigene (concentration 1:100) at the beginning of the breeding season.
- Dedicated incubation room lab coats or coveralls are essential, hair nets and slip-on shoes should be worn. This clothing should be renewed or washed regularly and not be worn in any other room.
- Long hair should be tied back and contained within the hair net used.
- Watches and jewellery should not be worn in the incubation or hatch room and should be removed prior to washing.
- Hands need to be washed and sanitised prior to entering the incubation room, but there should be washing facilities inside the incubation room as well to allow for the regular washing of the room surfaces and the equipment used within the room.
- It is not necessary for gloves to be used when handling kiwi eggs in the incubation room.
- The outsides of all incubators are to be cleaned/wiped weekly throughout the incubation season. Incubators are to be thoroughly cleaned at the start and end of the season and washed during the season when empty.

6.3 Hatch Room

Currently, in most kiwi ONE facilities, hatching occurs within the incubation room. A separate hatch room is desirable (but not always available) in reducing potential pathogens and contamination during and following the hatch process. A separate hatch room has very much the same strict hygiene conditions as the incubation room as seen above.

- Incubators used for hatching should be cleaned with Sterigene (or another suitable disinfecting product) as soon as the chick is taken out to the brooder room and before a new egg is placed into the incubator.
- Gloves should be worn when handling newly hatched chicks.
- Any hatchers that have held a sick or dead chick will need extra care taken with disinfecting, as will any equipment used in relation to the sick chick.

6.4 Annual Clean of the Incubation and Hatch Facilities

All incubators, hatchers, bench top surfaces, floors, walls, ceilings, and all equipment used, are to be thoroughly cleaned prior to the start of the kiwi breeding season. Sufficient time must be allowed to set up all incubators and hatchers in order to do any maintenance and calibration and fine tune temperature settings prior to the commencement of egg incubation.

- Wash all the walls, ceilings, and floors using Sterigene (1:100 concentration) Leave the Sterigene on to air dry and then rinse the surfaces thoroughly.
- Wash all incubators and hatchers with Sterigene (1:100 dilution rate) and rinse thoroughly.
- Check and clean any air-conditioning units and check and replace the filters (if necessary). All air conditioning units should be regularly cleaned (monthly) and serviced every year.
- Wash all matting and clothes used in the incubator and brooder rooms in Sterigene and rinse well. Replace any lab coats, overalls and matting that are damaged.
- Wash absolutely all equipment in the incubator and hatch room(s). Care must be taken when washing fragile thermometers, wet bulb thermometers and wicks, candlers, weigh scales and items that have been specially calibrated.
- At the completion of the kiwi egg incubation and chick rearing season, all incubators, hatchers and brooders, and all surfaces should be thoroughly cleaned using the same procedure as carried out before the season and appropriately stored to maintain hygiene.

Minimum Standard 2.
Hygiene in incubation and hatch room facilities

a) All incubation and hatch rooms (walls, floors, and ceilings) and all equipment must be thoroughly cleaned immediately prior to the commencement of the breeding season.

b) Incubators, hatchers, and brooders are to be frequently wiped and thoroughly cleaned between eggs and chicks during the season.

c) All egg preparation, incubator, and hatching rooms are to be kept clean.

d) Before any equipment enters the incubation room it must be cleaned with Sterigene (or other suitable disinfecting product).

e) The incubation room must have restricted visitor entry.

f) Personal hygiene protocols such as clothing and footwear changes, and hand sanitation must be adhered to.

7. Kiwi Egg Arrival Processes

7.1 Initial Egg Arrival

When eggs first arrive at the captive rearing centre, initial processing should occur in the egg preparation room NOT the incubation room. It is preferable that egg viability is assessed in a separate room and that dead eggs are not taken into the incubation room. Make sure the egg preparation room can be blacked out to ensure optimal candling and has egg washing facilities available.

- Ensure all bench surfaces, scales, and the candler, have been cleaned and disinfected. Place a clean mat (non-slip matting works well) on the bench and have all necessary equipment and paper work (egg arrival sheet) prepared on the bench.
- Staff and visitors should adhere to all hygiene rules as outlined in Chapter 5. Visitor numbers should be limited.
- Do not to place the egg transport box on the bench, this is to limit any possible disease risks from contaminants on the bottom of the box. Place it gently on the floor, away from any door to minimise risks of the box being knocked or damaged. Make sure the handle of the transport box does not bang against the side of the box, jolting like this can damage the membranes of susceptible eggs.
- Remove any rings and watches then wash, dry, and sanitise hands to handle the kiwi eggs. Gloves can be worn as an extra precaution.
- Determine if the transport box contains a temperature probe, and if so, record the egg surface temperature before the box is opened. Note where the thermal sensor was located (i.e., on the top or bottom of the egg surface, between layers of egg packaging etc).
- Handle all kiwi eggs gently and slowly and keep all movements smooth.
- Always hold a kiwi egg level (i.e., with the long axis parallel to the floor).
- Carefully remove the egg from the transport box. Make note of any unusual odours or colours of the shell as the egg is removed or unwrapped. Also make note of the temperature of the egg, does it feel cold to touch or warm.
- Place the egg on the bench and allow it to naturally centre and if not marked already, place a small pencil marking the uppermost position of the egg. Young eggs will not always centre themselves (because the air cell is small) so carefully check the orientation of the air cell when the egg is initially candled. Immediately observe the orientation of the egg and record degree and direction that the egg is off centre (i.e., 45° to right). Record all observations on a dedicated ‘egg arrival data sheet’.
- Make note of any movement seen from the egg as this will help towards aging.
- After centering the egg, place it on a clean non-slip mat.

- Record any information regarding the egg and the incubation behaviour of the bird(s) from the field staff or volunteer delivering the egg/s. This should include parentage, nest characteristics, egg retrieval methods (night versus during the day), the time the egg was removed from the nest, transportation type and duration. Briefly record how the egg was packaged (if unusual) and transported. Record any egg timer transmitter details, and details regarding a second egg (or chick) in the clutch (for example viable, dead-on arrival (DOA), left in the wild, etc). Record details of personnel delivering the egg/s in case there is a need to refer to them for further information. Most this information can be written down by the field staff present when the egg was lifted on an 'Egg Lift Information Sheet" you provide to all trusts and conservancies prior to the season starting.
- Briefly candle the egg to determine viability, fertility, if there has been any membrane damage and approximate stage of development. This initial candling should take no more than 3-5 seconds and is primarily to determine viability (the egg will be candled more thoroughly later to accurately determine embryo age).
- Examine the egg extremely carefully for cracks, both in the light by eye, and in the dark by candling, before washing the egg.
- If cracks are present, classify the severity of cracks (refer to section 9.2 on dealing with cracked eggs). If an egg has moderate to severe cracking it will be gently splashed with Incusan (or Chick Guard), rather than being submerged.
- Note the position and general impression of the cracks (new, old, clean, or dirty) and record these.
- Determine the unique individual egg ID code to write on the egg after it has been washed.

7.2 Washing the Kiwi Egg

Egg washing is a standard ONE practise. It is recommended that kiwi eggs are washed to remove any soiling from the nest before being placed in an incubator for artificial incubation. Some kiwi eggs can arrive at a facility in an extremely dirty condition. Washing eggs does not affect hatchability and it helps to minimise potential contamination. This is especially important when multiple eggs are incubated together in a large still air or force draft incubator.

The egg washing solution that has historically been used is called Incusan, there are alternatives, but they have, as yet not been used with kiwi eggs.

- Prepare the egg washing solution after assessing egg viability.
- The water temperature should be 35˚C (range 30-35°C) with an Incusan concentration of 20 ml/L (e.g., 40 ml of Incusan: 2 L of warm water). Mix the water and Incusan well to ensure a uniform temperature and concentration and record the water temperature before washing the egg.

- Put on gloves then wash the egg by fully submerging it in the Incusan solution for 30 seconds only. Gently remove all dirt/stains/field marks from the egg by hand but avoid vigorously rubbing the egg shell directly. If the egg still has caked-on mud after the first wash, a second wash maybe required (note: it may be necessary to use a soft bristled toothbrush to gently wipe/flick the contaminants off the shell or a clean wet paper towel, and the total wash time should not exceed one minute).
- Do not submerge cracked eggs. Follow the guidelines for dealing with cracked eggs (refer to section 8.2).
- After washing, gently pat the egg dry using clean paper towels, and place the egg on a new clean mat. Once the egg is washed, gloves may be removed but re-sanitise hands before handling the egg again.
- If washing multiple eggs, make sure the water temperature is checked before each egg is washed, and wash a maximum of four eggs in the same Incusan solution. If the water temperature cools below 30°C, make a fresh warm solution of wash water.
- Record all egg washing details and ensure that all other information has been recorded.

All relevant information must be recorded in the eggs' individual notes as these will follow the egg through incubation, hatching and chick rearing, until release, and form an important data set.

All viable eggs can now be transferred to the incubation room and prepared for artificial incubation.

Minimum Standard 3.
Initial processing of ONE eggs

a) All kiwi eggs must be candled to determine viability. If there is doubt regarding the viability of an egg it must be incubated for a brief period – up to 14 days for a fresh egg and at least 2 days for an older egg (>10 days old).

b) All eggs must be given a unique identification code upon arrival.

c) Eggs should be washed in cleaning solution at the appropriate temperature before being placed in an artificial incubator.

d) Accurate individual records for all eggs must be kept, including records for 'dead on arrival' (DOA) eggs.

e) All DOA eggs must be placed in a fridge until they are necropsied onsite or sent away for independent necropsy.

8. Egg Preparation for Incubation (Incubation Room)

Performance Standard 1.
Hatching success of viable ONE eggs.

a) At least 85% of viable eggs should be successfully hatched.

b) All viable eggs that do not successfully hatch should be sent to someone who is experienced in egg necropsy to accurately determine cause of death.

8.1 Processing a New Egg for Incubation

- Once in the incubation room, re-weigh the egg. This 'egg set weight' is extremely important as all weight loss calculations will be determined from this weight. The egg must be weighed and recorded accurately.
- Using the candler to illuminate the air cell, lightly draw in the air cell line with a pencil, and date inside that circle. Unusually shaped eggs (with bulges) may cause the air cell line to appear off centre, and this should be recorded. Kiwi eggs are often odd shapes, for example the air cell will very occasionally appear in the pointed end (or non-air cell end, NACE), when it should be in the blunter end. Or there may be creases (wrinkles) in the shell at the blunt end (NACE).
- Next, place the egg on the bench and allow it to find its natural resting position. Draw a solid vertical pencil line indicating the centre line orientation and top of the egg. Mark this from where the air cell extends furthest into the egg and down the length of the egg towards the non-air cell end (~3 cm line, refer to Figure 8).

Figure 8. Kiwi egg showing the marked air cell and centre line orientation (photo: National Kiwi Hatchery)

- If there are two eggs in a clutch, determine which egg is the 'older' of the two, and sequentially code the eggs accordingly. Check this carefully as some eggs may be quite close together in age (± 2 days). Write the identification code and number on the egg in pencil, preferably in a location that can be seen while the egg is in the incubator.
- Make sure the identification code is clear and legible.

- Then candle the egg thoroughly to determine the approximate age of the embryo. If available, use diagrams in the Kiwi egg candling workshop study guide (Bassett 2009) to aid you. It is important to make an initial estimation of the age of the embryo prior to the egg being set in the incubator.
- It is useful to draw detailed sketches of the development of the egg on the egg arrival sheet. Preferably at the time the eggs are processed (or at least within the first 24 hours). If an egg is very cold, allow it to warm up to incubator temperature before you draw the egg (2-3 hours to warm). This is a very useful data to refer to if there are problems (or mortality) in the later stages of incubation or hatching.
- Double check the entire egg for cracks and treat, if necessary, refer to Section 8.2. Also sketch the size and location of any cracks on an egg diagram as a permanent record in the notes.
- A photo of the egg is only required if the egg has a very unusual shape or appearance, is severely cracked, or has been repaired with a patch.
- Determine which incubator the egg is going to be placed into, either a still air incubator or forced draft incubator that uses an automatic turning systems.
- Severely cracked eggs should only be placed in a still air incubator, where the turning is manual and can be adjusted according to the severity of the cracking. Where moderately cracked eggs are to be incubated will be determined on a case-by case basis. No eggs are to be placed in a forced draft incubator if they have any cracks on the lateral sides, but a hairline crack along the top of the egg is acceptable.
- If the egg has suffered severe membrane damage and the membranes have detached from the shell, then this too will need to be placed in a still air incubator and the turning schedule adjusted for the degree of damage (refer to Section 9.1.2)
- Record the incubator temperature and relative humidity before you open the designated incubator. Then place egg into the appropriate position within the incubator.

8.1.1 Placing an Egg in a Still Air Incubator

There are various types of still air incubators that are available but historically the Brinsea Polyhatch incubator is the standard type of incubator that has been used for kiwi egg incubation. The information below is based on the Brinsea Polyhatch.

- Check that the incubator base trays are filled with distilled or cooled boiled water.
- Check the wet bulb thermometer is filled up and is reading correctly.
- Place the egg in the centre of the incubator, with the air cell facing away from you. This puts the egg in the correct orientation for candling in situ, if a quick check of development is required, and minimises unnecessary rotation of the egg when handled.
- Check the thermometer does not hit the egg when the lid is put down, and place support rods to either side, but just clear of the egg.

- Ideally there should be no more than two eggs placed in each still air incubator (unless in extreme circumstances and for a short period of time only). Care needs to be taken that the eggs do not come into contact with each other.
- Record the time the egg is placed in incubator, and how many eggs are present.

8.1.2 Placing Eggs in a Forced Draft Incubator

Again, there are various makes of forced draft incubator available and each has a slightly different system of positioning the eggs, turning and humidity control but the below procedures can be applied to all systems.

- Make sure that the egg is fitting snugly between the rollers/ dividers and that it is as level as possible. If the egg does not lie horizontally, place a small support (preferably foam) at the non-air cell end of the egg so the egg sits level. Eggs should fit firmly between the dividers. Always adjust the divider spacing with the egg removed.
- Record the time the egg is placed in incubator, and how many eggs are present.

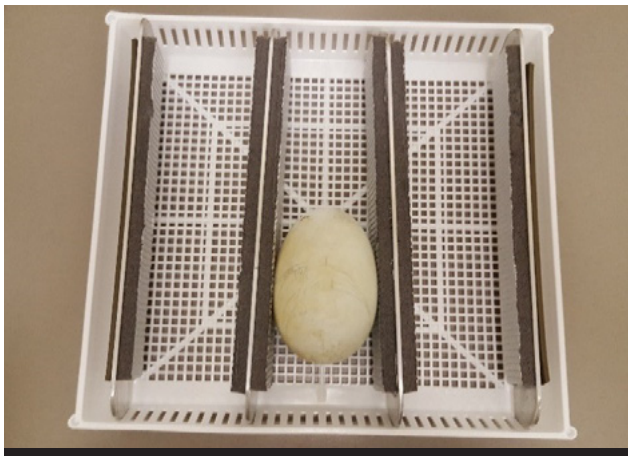


Figure 9: Egg placed in Brinsea Ova Easy tray with padded dividers (Photo: West Coast Wildlife Centre)

Minimum Standard 4.
Processing an egg for artificial incubation

a) All kiwi eggs must be candled to determine an approximate embryo age prior to the egg being set in the artificial incubator.

b) All eggs must be clearly labelled with the correct identification code specific to that egg only.

c) All eggs must be placed in a suitable, clean incubator set to the correct temperature and relative humidity conditions.

d) All incubators must have an accurate thermometer.

e) Egg viability must be determined as outlined in Minimum Standard 3.

f) Accurate individual egg records must be kept for all eggs.

g) All 'dead on arrival' eggs must be placed in a fridge until they are sent off for independent necropsy.

8.2 Dealing with Cracked Eggs

Cracked eggs are a potential source of bacterial contamination. The risk is not only directly to the egg itself (bacteria getting in) but also to other eggs becoming infected when sharing an incubator with a damaged egg, (this only occurs if the bacterial contamination goes undetected). Even when repaired, cracked eggs can be a continual problem (high weight loss during incubation, increased risk of infection, hatching difficulties and yolk infections post-hatch) so they must be monitored closely.

- Make sure you differentiate between an external pip (shell pushed out) and an impact hole (shell caved in). This is especially important if the hole is situated within the air cell.
- Quantify the degree of shell damage and map the type of cracks.
- Severely cracked eggs should only be incubated by themselves in a still air incubator, if possible. This avoids contamination of other eggs and allows the incubator conditions to be managed to meet the requirements of the egg.
- Eggs that have small cracks (star cracks and small hairlines) can still go into a forced draft incubator if repaired, but they must not have any cracks on the lateral surfaces of the egg, where pressure from the dividers/rollers will potentially result in further cracking during automated egg turning.

8.2.1 Washing Cracked Eggs

- If an egg is found to be cracked on initial candling, do not wash the egg by fully immersing it in the water. The egg should only be lightly splashed with warm Incusan solution (20ml/L) away from cracked areas, or the surface of the shell gently wiped over with gauze or tissue moistened with Incusan solution. If cracking is restricted to the upper surface of the egg, you can partially submerge the lower surface of the egg during washing.
- If there is an actual hole in the shell, be extremely careful not to get water in the hole. Carefully wash around the damaged area with a cotton bud dipped in the Incusan solution, before washing the remainder of the egg surface (with splashing or partial submersion).
- After the egg has been washed, pat dry the cracked egg extremely carefully.
- Once the egg is clean and dry, you can then seal or repair the cracks (see section 8.2.3). But the shell must be totally dry, or the varnish/tape used for sealing the cracks will not stick to the shell.
- Occasionally you may be washing a particularly dirty egg (caked on dirt in a specific spot) and as the dirt is removed the damaged area suddenly becomes exposed. Stop submerging the egg and proceed carefully with the remainder of the egg preparation.

8.2.2 Definition and Degree of Egg Damage

- Star cracks: tiny cracks (<2 mm) that look just like a 5-point star.
- Hairline cracks: 1 to 2 cm line of tiny fine cracking, almost indiscernible. These cracks are often difficult to see but it is helpful to shine the candling light across the surface of the shell (not hard up against it) to help identify them.
- Moderate cracks: moderate 2 – 4 cm line of cracking, includes multiple cracks or one long hairline crack, and multiple branching. Moderate damage also includes a substantial single long crack (with no branched cracking and can be up to 6 cm in length).
- Severe: multiple branching (5+ joining cracks). These cracks always require taping. Severe damage may also include holes which require patching.
- Holes: holes include a small impression in the shell (for example from an adult toenail), through to exposed and damaged membranes. There may be bleeding, and these holes require careful patching, either with tape, or another piece of shell.

8.2.3 Preparation and Treatment of Cracked Eggs

- Make sure the egg is dry before sealing cracks with nail varnish or tape.
- Care should be taken when repairing cracks so that the varnish or tape does not inhibit the chick's ability to hatch successfully. Especially if there are multiple cracks in the air cell. In this situation it is often preferable to use nail varnish only rather than tape, but if tape is required then be aware it might need removing as the chick initiates the hatching process.
- If cracks are present, gently 'map' the outline of the cracks on the shell with a pencil as an indicator as to where the cracks are for future handling of the egg. Do this carefully as the shell will be more fragile once it has been damaged. With star cracks just faintly circle them.
- Use clear nail varnish only. When sealing the crack with nail varnish, use enough to properly seal the crack but not excessive amounts that will run over the shell.
- Moderate cracks can be sealed with nail varnish but may not always require taping. This depends on the type and location of the cracks.
- Severe cracks can be sealed with nail varnish, carefully covered with masking tape (i.e., Scotch masking tape) and then the edges of the tape also sealed with nail varnish. The width of the tape required will change depending on the severity of the cracks, (smaller cracks require narrower tape). Remember to smooth out any air bubbles in the tape if possible, without causing further cracking.
- Multiple branching fractures should be covered with a piece of tape to help strengthen the most cracked area, and then the tape edges sealed with nail varnish. In certain situations, if the crack is extremely dirty, it will be necessary to coat the entire piece of tape in nail varnish to completely seal the area.

- Badly smashed eggs can have the shell of another egg taped over the damaged area. Keep some pre-washed and fully dried pieces of kiwi egg shell (using Sterigene (20 ml/L) ready in the incubation room so they are available for patching. Select a piece of shell from a corresponding area of the shell you will be patching. The patch must be larger than the non-fractured area of shell around the hole or extensively cracked area. If you are able, remove any badly cracked pieces of shell without damaging the shell membrane or the vascular chorio-allantoic membrane underneath then do so, but be extremely careful. Place the patch over the damaged area and using small narrow pieces of tape, tape the entire perimeter of the patch to the shell, (refer to Figure 10). Seal the edges of the taped area with nail varnish. Do not seal the whole patch as this will affect the rate of weight loss.

Figure 10: A severely damaged egg that was successfully patched and subsequently hatched (Photo: National Kiwi Hatchery)

- If the chorio-allantoic membrane has been damaged and is bleeding, keep the smashed area upright irrespective of correct egg orientation and carefully assess the damage. If it is haemorrhaging badly, contact a qualified veterinarian[1] for additional advice as a decision will need to be made whether the egg is repairable. It is possible to repair severe cracks and holes and still successfully hatch a chick, but in rare instances where extremely severe damage has occurred euthanasia of the embryo may be the only option.
- If it is a small, localised bleed, wait until it has stopped bleeding and then patch.
- Do not apply direct pressure to the area as it may result in further damage to membranes. Instead, place a 'Telfa' non-stick pad gently over the area until the bleeding stops.
- Bacterial contamination is a serious risk with any cracked egg, so it is important to carefully wash around the damaged area to minimise this.

Figure 11: A severely damaged egg that was subsequently euthanased (Photo: Suzanne Bassett)

Minimum Standard 5.
Treatment for Cracked Eggs

a) All cracked, and damaged kiwi eggs must be repaired, either by an accredited handler or are being trained to do so, by an accredited trainer.

b) Any egg that is so severely damaged and bleeding, and where survival is highly unlikely, must be euthanased.

[1] Or contact either the Wildbase Hospital, Massey University, Palmerston North, or the Centre for. Conservation Medicine at Auckland Zoo for advice

9. Protocols used in the Incubation Room

9.1 Artificial Incubation Parameters

All kiwi eggs are light sensitive and are to be kept in semi-darkness, except when you are working in the incubation room (when the lights can be fully on). It is not recommended to use red light bulbs, or head lamps when working with kiwi eggs in a captive facility. Keep incubation room lights dim throughout the day and all internal incubator lights (if applicable) turned off. All incubation room lights should be turned off at night.

It is acknowledged that the success rate of incubating a kiwi egg from fresh to hatch is low and there is still research to be done using different parameters during early incubation to maximise hatching rate. But below are the known systems used for both still air incubation and forced draft incubation with kiwi eggs in New Zealand.

9.1.1 Incubator Protocols used.

Table 2. Incubator parameters for kiwi eggs.

Training Module Number	Task Description	To be Accredited you need to have seen and done:	# of tasks completed to become a trainer
Forced draft	Age of arrival – internal pip	33.5°C	Automatic: 8 turns per day, total of a 90° turn angle
Still air	Day 1 – day 40 (Or once the CAM has met- used by the National Kiwi Hatchery)	36.5°C	Manual: 4 x 45° turns per day then automatic turning 4 x 22° turns at night.
Still air	Day 35 to 40 – Internal Pip	35.5°C	Manual: 4 x 45° turns per day until internal pip
Still air & forced draft	Hatching	33.5°C (Auckland Zoo 35.5°C to 36.0°C)	No turning

9.1.2 Turning Regime for Eggs in the Still Air Incubators

Day 1 Fresh to day 40

Eggs are turned manually four times during the day. Each turn is 45 degrees and is spaced evenly throughout the day. During the night the automatic turning system is scheduled to switch on to turn the egg four times during the night, though the degree of turn is less than a manual turn (approximately 22 degrees).

Day 40 to Internal Pip

Once the chorioallantoic membrane (CAM) has met under the egg, from approximately day 35 to day 40, eggs can have the turning reduced to just the four times during the day. With the turning at night being switched off.

Manual Turning Methods

On day 1: Manually lift and turn the egg slowly, **45° anti-clockwise** (to the left) for turns 1 and 2, and then clockwise (to the right) for turns 3 and 4. This always returns the egg to the correct upright orientation at the end of the day. The maximum distance the egg is turned each day is 90°.

On day 2: Manually turn the egg **45° clockwise** (to the right) for the first two turns, then anti-clockwise (to the left) for turns 3 and 4, so the egg returns to the same position it was in at the start of the day.

Alternating the direction of the first egg turn of the day prevents the egg from continually being rotated the same way each day. Continue to turn the egg up to internal pip.

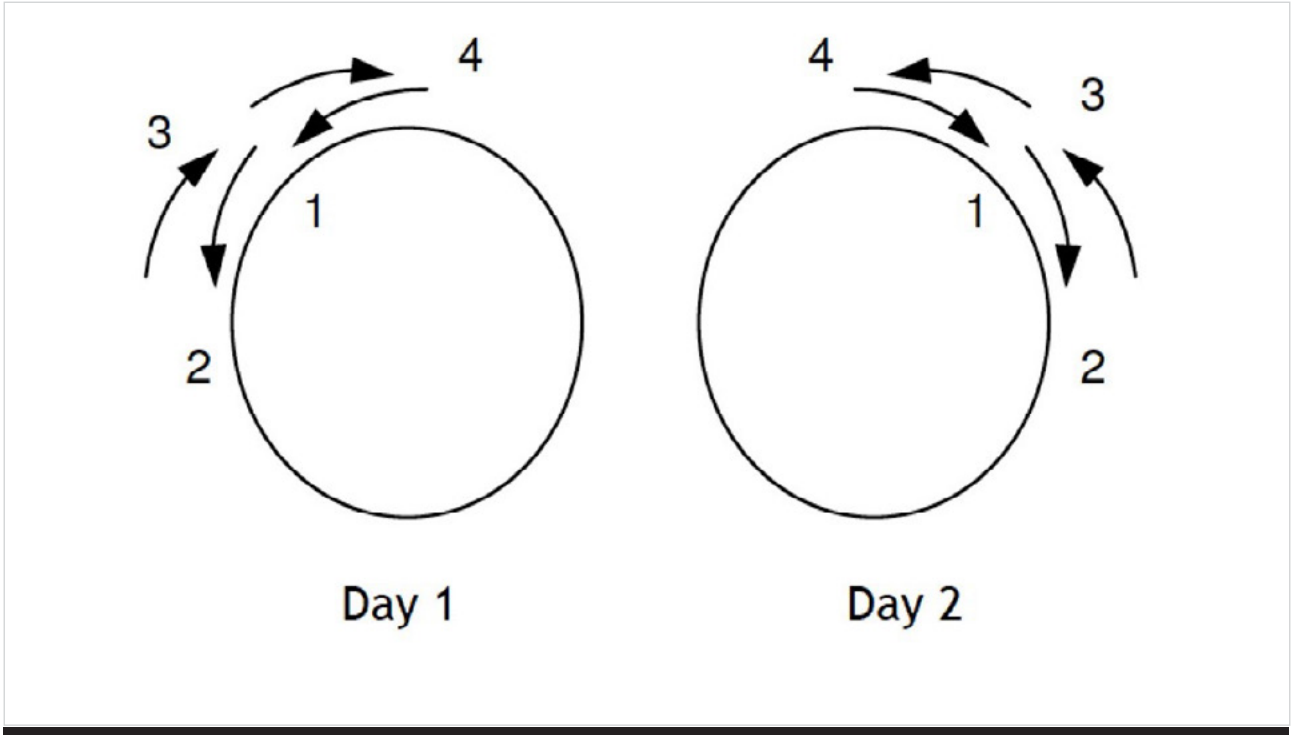


Figure 12: Manual egg turning regime for kiwi eggs.

The only time it is advised that kiwi eggs are not turned according to the above schedule is when the egg has suffered severe cracking and/or membrane damage, the chick is malpositioned or the egg has been artificially internally pipped.

- For an egg with severe membrane damage, it is better to tailor the turning to reduce the risk of further detachment of the membranes, this might mean the egg is turned as little as 20° though some movement is essential especially with the younger embryos.
- Chicks that are malpositioned may need the turning regime changed but usually only very late in incubation or when artificially internally pipped.
- When eggs have been artificially internally pipped and found to be very wet or 'sticky'. It is important in these situations to lift the lid regularly on the still air incubator to ensure adequate air exchange (3-4 times per day).

9.1.3 Parameters for Forced Draft Incubation

It is important the forced draft incubator temperature and humidity is recorded four times per day. Temperature and humidity parameters need to be set very carefully considering the type of incubator used, the air exchange levels in the incubator, and the number of eggs being incubated. Most forced draft incubators have a fully automated system of turning the eggs which is activated via a 24-hour timer on the top of the incubator itself. This should be set to turn the eggs 8 times in a 24-hour period at regular intervals throughout the day and night. The egg trays sit inside a frame that will turn a full 90° when the timer has been activated (45° right to 45° left through the central orientation of the egg).

9.2 The Daily Incubation Regime

9.2.1 General Daily Regime

- Follow all quarantine protocols when working in the incubation room to maintain as clean an environment as possible.
- Monitor the incubation room conditions (temperature/relative humidity). This is especially important when using still air incubators. All incubation rooms should be at a constant temperature and relative humidity to minimise the effect of outside influences on the incubators.
- Record all incubator parameters, top up water reservoirs, and ensure that all incubator lids are properly closed.
- Allow only trained and designated people to carry out incubation room tasks and handle eggs.

9.2.2 Still Air Incubation Daily Regime

- Record the temperature and humidity the incubator is running at, at least twice daily (but preferably four times per day). Record this prior to lifting the lid (or opening the door) of the incubator. You must be able to read the thermometer without lifting the lid.
- The temperature in the still air incubator should be set as per the facilities parameters, and this should remain constant. Staff should be familiar with the operation of the incubators used at their facility and able to adjust both temperature and humidity if required.
- Outside weather conditions can have a small effect on the still air incubator temperature and relative humidity of the incubation room. Monitor the temperature at least twice before adjusting the temperature control. If the temperature is adjusted, it should be noted on the data sheet indicating the temperature has been increased or decreased.
- If wet bulbs are used to monitor relative humidity, they must be placed so that staff are able to read the scale without lifting the incubator lid. The wick should just be over the bulb of the thermometer (not pushed up any further). Make sure that the wick of the wet bulb is not touching the side of the incubator, as this will alter the correct reading.
- Check and top up all incubator humidity and wet bulb reservoirs with distilled water or cooled boiled water, if necessary.
- Turn eggs as required (refer to Section 9.1.2) at designated times. For example, manual egg turning times can be 8.15 am, 11.15 am, 2.15 pm and 4.00 pm. Eggs must be handled gently, and sudden jarring movements avoided.

An example of a daily manual egg turning regime in a still air incubator

Day 1

8 am:
- Record incubator temperature and humidity
- Turn eggs to the left 45° (turn 1) accordingly

11.15 am:
- Record incubator temperature and humidity – adjust if necessary
- Turn eggs to the left 45° (turn 2) accordingly

2.15 pm:
- Record incubator temperature and humidity
- Turn eggs to the right 45° (turn 3) accordingly

4.15 pm:
- Record incubator temperature and humidity – adjust if necessary
- Turn eggs to the right 45° (turn 4) accordingly

9.2.3 Forced Draft Incubation Daily Regime

- Record the forced draft incubator temperature and humidity (actual, set points and functioning %), and the orientation of the eggs (i.e., left, or right) four times per day.
- Check all wet bulb reservoirs, if using, each time the incubator is opened. Fill with distilled water if necessary.
- Eggs that are very close to hatch need to be briefly checked early in the morning and late in the afternoon (i.e., 8am and 4pm). Unless there is concern regarding the degree of embryonic movement, the eggs can be quickly candled in the incubator. Avoid bringing the eggs out of the incubator unnecessarily.

9.3 Egg Weighing and Candling Day Regime

Ideally kiwi eggs only need to be weighed twice per week to accurately determine egg weight loss using the weight loss calculation. It is not necessary to weigh ONE eggs every day.

- Weigh days should be spaced as equally as possible, for example Tuesdays and Fridays. It is preferable not to have the egg weigh day falling at the weekend when staff numbers are often reduced. All eggs should be weighed at the same time on each weigh day, and it is preferable this is carried out in the morning.
- Remove egg from the incubator (or incubator trays) and weigh (to the nearest 0.1 gram). Record weight carefully.
- Place the egg directly on the bench and visually check for embryonic movement (clearly detectable from day 45 onwards). At the later stages of development (65+ days) these egg movement should be very obvious, but it still may be necessary to whistle at or talk to the egg to stimulate embryonic movements. Record if movement occurred and place the egg onto a non-slip mat on the bench.
- Calculate egg weight loss and assess whether it is within the correct parameters (refer to Section 9.5). It is essential that you refer to the previous weight loss, and the overall weight loss trend, to gain proper insight into how weight loss is progressing for each egg. This should be completed on the actual weigh day, and should be denoted with an arrow (↑ , ↓ or NC - no change) depending on how the weight loss percentage has changed. Do not continue to calculate egg weight loss once an egg has internally pipped.
- Prior to candling the egg, quickly familiarise yourself with the egg notes from the previous candling session in order to compare the developmental progression. This saves repetitive notes and helps to keep the candling duration short.
- Candle all sides of the egg carefully. Record notes on developmental progress and draw if necessary. It is useful to record early stages of development, up to 30 days, or any unusual development. If you add additional notes on the back of the data sheet, remember to include the date of the observations and initial them. It is essential to document all egg developmental changes as hatching approaches. Important observations include the general appearance of the vascular system, good embryonic movement, shadowing, evidence of drawdown, and internal and external pip.

- If there has been a noticeable or marked increase in the air cell size, then draw in the new air cell and date it.
- Check egg orientation (and centre line) only re-draw the centre line if there has been a marked change (1+ cm from original centre line). The egg will normally pull to the left, the new centre line will be to the right of the original one. Use a dashed line as opposed to a solid line when you redraw this.
- For still air incubators, check there is sufficient water in the trays at the bottom of the incubator and in the wet bulbs to maintain humidity levels before replacing the egg.
- Return the egg to the incubator and turn the egg accordingly.

Minimum Standard 6.
Monitoring kiwi eggs during incubation

a) All kiwi eggs must be continually incubated under correct and constant incubation conditions and in a clean environment.

b) All incubation parameters must be followed, and egg orientation must be recorded daily for each egg.

c) Each kiwi egg should be candled twice per week to assess progressive development.

d) From day 45 onwards eggs should be visually checked to confirm embryonic movement at least twice weekly. This should occur during egg candling.

e) Accurate incubation records must be kept for each individual kiwi egg and records must be maintained daily.

f) All staff should be accredited in egg incubation and candling.

9.4 Egg Monitoring Points

When there are a lot of eggs in incubation, it is useful to have a system or order in which the eggs are candled. It is usually easier to candle all the eggs close to point of hatch first (post internal pip) so that any problems can be identified early in the day. Then work from the youngest eggs to the oldest (pre internal pip). It can be helpful to maintain this order of age when placing eggs in the trays in a forced draft incubator, or a large still air incubator, as it is useful when candling to be able to compare eggs at similar stages of development, especially when accurately assessing embryo age.

9.4.1 Late Embryo Development (~ 70+ days)

Once full drawdown is detected the egg should be briefly candled early in the morning in order to determine if internal pip has occurred. This brief candle is just necessary to detect bill movement in the air cell, if the bill tip is visible, and then possible clearing out (lightening) on the top central surface of the egg.

If there is a potential problem with an egg in the morning, i.e., there is minimum movement, or the veins look fine and stretched, it is important not to wait until late in the afternoon to address it. The egg should be observed mid-afternoon (i.e., 2pm) so there is adequate time to get an x-ray taken or assist in some way if necessary.

9.4.2 General Embryo Development (0 to ~ 70 days)

Follow the same weigh and candling procedure as outlined above for older eggs that are close to hatching, candling the youngest eggs up through to the oldest eggs.

In eggs less than 45 days, embryonic movement will not be detectable by eye (though it can usually be detected by 'strawing' if required, where a fine metal rod is placed lengthwise across the egg). Movement should be checked for all eggs 45 days and older.

Do not have large numbers of eggs out on the bench during weighing, e.g., a maximum of 6 eggs only, out at one time. Never place eggs so they can potentially roll off the bench. All eggs must rest on non-slip matting when out on the bench.

9.5 Egg Weight Loss

A kiwi egg should lose on average between 14-18% of its fresh weight before it internally pips, (minimum 12%, maximum 22% as a general guide). With eggs arriving from the wild at differing stages of development it is difficult to accurately determine the fresh weight of the egg, or how much weight it has already lost during natural incubation, so it is necessary to calculate actual weight loss during artificial incubation. Historically eggs were weighed daily, and the egg loss extrapolated as a form of density. It is now recommended that the weight loss calculation outline below is used (see 9.5.2.)

9.5.1 Humidity Control

Humidity must be controlled in the incubators to maintain the correct loss of water vapour from the egg. For Brown Kiwi to maintain the weight loss percentages mentioned above the relative humidity should be maintained on average at 60-65%RH.

For Haast Tokoeka and Rowi the humidity requirements during incubation vary to the Brown kiwi eggs. Haast Tokoeka need a much lower relative humidity being incubated at 45RH% on average and Rowi require a higher humidity rate of 65-70%RH (See section 9.5.3 on adjusting the humidity within the incubator)

To work out the actual weight loss percentage for an egg during incubation, the kiwi egg is weighed twice a week and weight loss calculated using the formula below. If the weight loss does not fall within the correct range for kiwi eggs, then action is required. For still air incubators the humidity levels should be adjusted, while for forced draft incubators, the moisture loss of the egg should be adjusted by taping the egg.

9.5.2 The Weight Loss Calculation

This formula calculates what the total percentage weight loss of the kiwi egg, throughout the entire 78-day incubation period, will be based on the current daily rate of weight loss and the length of time the egg has been incubated. This calculation can be performed irrespective of an eggs age and the fresh weight of the egg when it is laid.

What is most important is the actual set weight when the egg first enters the incubator and the actual number of days the egg has been artificially incubated for.

Estimated total percentage weight loss = [(Set weight – egg weight on weigh day) ÷ (set weight x 100)] ÷ (the number of days artificially incubated x 78 days)

A simple example:

Set weight of the egg = 396.0 grams

Set date (day artificial incubation started) = 1 November 2022 (day 0)

Weight of egg on 6 November 2022 = 391.5 grams

Number of days the egg has been incubated artificially = 5 days

396.0 grams (set weight) – 391.5 grams (weight on day 5) = 4.5 grams (total grams

lost over 5 days)

4.5 g ÷ 396.0 grams (set weight) = 0.0114 grams (total weight lost as a proportion of the set weight)

0.0114 x 100 (to convert to %) = 1.1364 (total weight loss as a %) 1.1364 ÷ 5 (number of days egg incubated) = 0.2272 (average % daily weight loss)

0.2272 x 78 (incubation period) = 17.7 %

Therefore, on 6 November the egg is on track to lose a total of 17.7% of its weight over the artificial incubation period.

396.0 grams – 391.5 grams = 4.5 grams 4.5 grams ÷ 396.0 grams = 0.0114

0.0114 g x 100 = 1.1364 1.1364 ÷ 5 = 0.2272

0.2272 x 78 = 17.7 %

It is not necessary to weigh eggs every day, but it is important to accurately determine the weight loss percentage, and to closely monitor all weight loss during artificial incubation. In general, weight loss should be fairly consistent throughout incubation, though it can take a few days for the egg to settle into the artificial incubation conditions.

It is also not necessary to use density predictions of weight loss, as this is an outdated method. The actual weight loss formula above is more accurate and simpler to use, resulting in fewer errors and a greater regulation of egg weight loss during artificial incubation.

Try to avoid leaving eggs in a high humidity environment for long periods of time, particularly late in the incubation, as it can cause splayed legs and toes. Humidity should remain stable and constant without fluctuations. Incorrect humidity and weight loss during incubation can lead to major problems during hatching. Insufficient weight loss leads to oedematous chicks. Indicators of this are a very sticky wet hatch, and weak chicks with fluid filled tissue around the neck, shoulders, and thighs.

9.5.3 Maintaining the Correct Weight Loss of an Egg

When egg/s are set in the Brinsea still air incubator, ensure the base trays are filled with water to maintain the correct relative humidity, and record the relative humidity inside the incubator at least twice a day. It is important not to restrict the air flow into an incubator by covering the ventilation holes in the lid or base.

Egg weight loss calculations are initiated once artificial incubation is started. An egg will usually take a few days to adjust to the artificial incubation conditions but can take up to a week. So, it is important to assess how weight loss is tracking, over an average of at least two 'weigh days' (a maximum of three 'weigh days' over a three-to-seven-day period) to determine how weight loss is progressing.

As stated, the average weight loss of any given egg should fall within the parameters of 14-18%, though some eggs can reach a minimum 12% - max 22%.

There is no need to continue to weigh the egg or to calculate weight loss once the egg has internally pipped, as this becomes irrelevant once the chick commences pulmonary respiration.

In the still air incubator, the weight loss of an egg is controlled by adding or removing water from the trays to influence the humidity within the incubator. To increase humidity, increase the surface area of water in the trays (add more water trays if required). This will result in the egg losing less weight. To decrease humidity, reduce the surface area of water in the trays (remove or empty trays). This will result in the egg losing more weight.

For a forced draft incubator. the humidity can be changed using the digital controls. In an ideal environment it is better to have several forced draft incubators all working at varying humidity levels, so eggs can be placed in an environment that best suits their weight loss requirements.

It is useful to record when, and how many water trays are added to or removed from a still air incubator (shallow plastic trays are ideal for this). It is best to add 3-4 small water trays initially (as any fewer has a negligible effect on the relative humidity). It may take up to a week to see any changes. Egg weight loss should be monitored closely and altered gradually. Additional trays (2 to 4 slide trays at a time) can be added as necessary.

If adding water trays does not lower the weight loss enough, then it will be necessary to tape the egg (using only masking tape) to reduce the amount of water being lost during incubation (procedure listed below). This technique is also applicable to eggs losing excessive amounts of weight (above 20%) while incubated in a forced draft incubator.

9.5.4 Reducing Excessive Weight Loss in Eggs with Tape

The stage of embryo development is an important consideration when deciding to tape eggs. Eggs at a late stage of development (70+ days) should not be taped. Careful assessment must be made before beginning to tape any egg.

- Use clean masking tape only (do not use insulation tape or regular Sellotape as they are too impervious to water vapour).
- Make sure you weigh the egg immediately before you start applying tape to the shell, and re-weigh when the taping is completed. It is essential to record and highlight the new egg weight on the egg data sheet. Remember to deduct the weight of the tape first before calculating egg weight loss.
- The taping should start along the lateral line (side) of the egg from the air cell line straight around to the non-air cell end on the left-hand side of the egg. If weight loss is still too high and more taping is required, then tape from the non-air cell end around the lateral line of the egg (on the right-hand side) up to the air cell. The second piece of tape is now directly opposite the first piece of tape.
- As you are applying the tape to the shell gently press out all air bubbles and wrinkles. Handle the egg extremely carefully and smooth the tape out gently.
- When taping an egg, start by adding 1-2 pieces of tape, and closely monitor weight loss over the next few days. If it is still too high, then add another 1-2 pieces of tape and again monitor. If necessary, more tape can be applied, but this needs to be done gradually allowing the egg time to adjust its weight loss. Up to 50% of the non-air cell area of the shell can be taped but it is important to make sure that gaps are left between each line of tape.
- When taping the underside of the egg, it is important to tape on either side of the bottom of the egg. This will allow the egg to continue to move freely and orient itself correctly when placed on the bench. Leave taping the top surface of the egg until last, as it makes candling much easier.
- It is important not to tape into the air cell region.
- From external pip onwards, the tape can gently be removed so it does not hinder the normal hatch process.

9.5.5 Insufficient Egg Weight Lost

If eggs are losing insufficient weight in a still air incubator, they should be set up in an individual incubator and the relative humidity level reduced to correct the weight loss. This is a rare occurrence and eggs have successfully completed incubation, but careful monitoring is required.

If an egg is losing insufficient amounts of weight in a forced draft incubator, and there is no opportunity to move it into another unit with a lower relative humidity, it will be necessary to move it into a still air incubator and monitor weight loss accordingly.

Minimum Standard 7.
Monitoring weight loss during incubation

a) Each kiwi egg must have weight loss monitored at least twice weekly during incubation, and incubation parameters adjusted as necessary to ensure an appropriate level of weight loss.

b) Where egg weight loss is very high, the relative humidity parameters must be increased, or tape should be applied to the egg to reduce the weight loss.

c) Where weight loss is too low, the relative humidity should be decreased.

10. Kiwi Egg Development

In general, the incubation length for Brown Kiwi eggs is 75-78 days under artificial incubation conditions. There is a real need to continue to collect quality incubation and chick rearing data for the South Island species of kiwi where available data is currently limited.

Kiwi egg development will not be covered in detail in this document. Rather, it is required, as part of the accreditation process, that all staff responsible for incubation in a captive rearing centre, will have attended the Save the Kiwi Operation Nest Egg™ kiwi egg candling workshop and are able to determine the age of kiwi eggs, as well as whether there are any problems with the development of the chick.

10.1 Characteristics of Live 'Young' Eggs (0 - 30 days)

- Young kiwi eggs have a small to medium-sized crisply defined air cell.
- At this stage the embryo can often be seen lying just under the shell on top of the egg.
- An obvious chorio-allantoic membrane (CAM) full of fine bright red veins, can be seen progressing across the top and down the sides of the egg in a large ring, radiating from where the embryo is usually found.
- The egg has an orange-yellow glow at the top but beneath this vein network (going down the sides of the egg) it is still very translucent, and development is very easy to see.

10.2 Characteristics of Live 'Older' Eggs (~55+ days)

Eggs that are over about 55 days of age look very different when candled, compared to younger eggs, and some of the main characteristics are described here.

- As the embryo develop the air cell increase in size from a medium to large, to a very large sized, crisply defined air cell.
- As the egg gets older the main body of the egg appears to darken in colour from a deep red to almost black when candled and you can only just determine different structures within the egg.
- The band of veins immediately below the air cell start reducing from a width of about two centimetres down to less than half a centimetre. These veins will still be evident if the top of the egg is candled. The important thing is that the egg appears dark with a deep red/orange glow at the non-air cell end.
- Once the egg is 70+ days, the air cell is huge (i.e., at least a third of the way down from the top of the egg) and the band of veins directly beneath the air cell on top of the egg are in a 'W' shaped and the veins themselves are very fine, if visible at all.

- There is still a glow at the NACE (non-air cell end), with some veins still obvious. Waste deposits (looking like patches under the shell, usually at the NACE) are also evident. At this stage, it is important to continue to monitor embryonic movement.
- The air cell can be candled to look for indications that internal pip has occurred. The egg should be held horizontally, with the air cell facing away from you. In this position the bill should be on the left-hand side of the egg within the air cell, and often close to the shell surface. The embryo moves a lot at this stage, so the bill shadow may not always be obvious.
- In the very late stages of incubation, after internal pip, it is possible to listen for chick vocalisations from inside the shell. The embryo can be stimulated to either vocalise or rock the egg by whistles.
- Close to hatch the egg has lost the very dark look and is now looking much paler red yellow and cracking in the air-cell will be visible.

Minimum Standard 8.

a) All staff members at a captive facility that are involved in the artificial incubation of kiwi eggs must attended the Save the Kiwi Operation Nest Egg™ Best Practice Ex-Situ Practitioners Course (in kiwi egg candling) and is familiar with the stages of kiwi egg development.

b) All staff must be accredited in kiwi egg incubation as part of the KAH certification

11. Kiwi Hatching and Post Hatch Care

11.1 Hatching

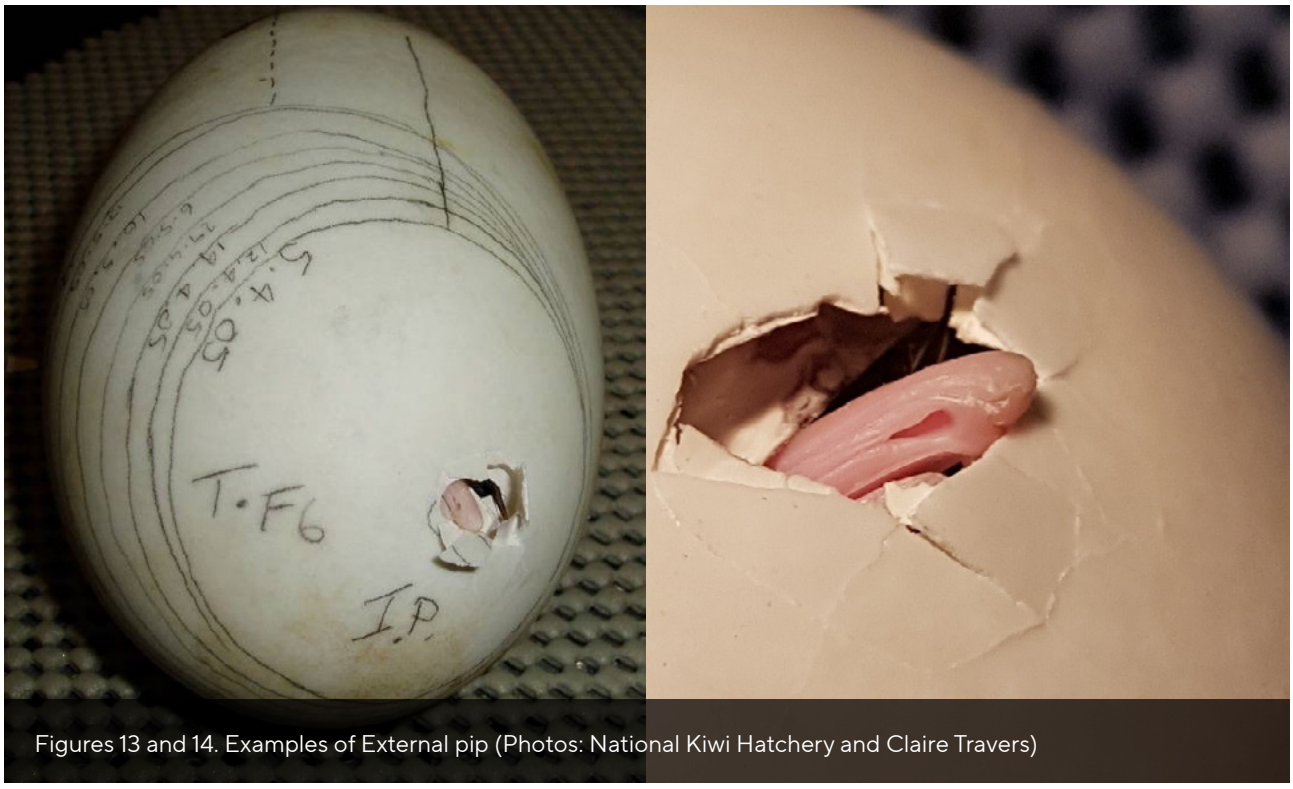
The routines outlined in this section have proved to be successful with constant refinements and adaptive management techniques since Operation Nest Egg (ONE) commenced as a kiwi conservation tool. Well over 2000 kiwi chicks have been hatched throughout New Zealand as part of Operation Nest Egg procedures and a hatching success of 90+% can be consistently achieved from all viable eggs incubated artificially. It must be remembered that every egg is an individual and as a consequence each hatch process will vary to a certain degree with each egg. The below sections are guide lines to be used.

11.1.1 Hatching Procedures

Kiwi eggs are currently hatched in a variety of still air and forced air incubators around the country. Hatching methods are variable but should eventually be standardised. It is advocated that eggs can be moved from a standard incubator into a hatch incubator from either internal pip or external pip. The important factor is to maintain the humidity during the hatch process, so the egg membranes do not dry out.

- If using a still air incubator as a hatcher it should be fully prepared, clean, dry and with a constant temperature and humidity as per the facility protocol.
- Ensure that the hatching egg is by itself if in a still air hatcher.
- There must be only one egg per compartment in a forced draft hatcher tray (and, depending on the configuration of the trays no more than four individual eggs per tray or shelf).
- The optimal hatcher temperature is 34°C (maximum temperature of 35.5°C is used at some facilities, with a minimum temperature 33.5°C used at others) and must be constant before the egg is placed in the hatcher. Humidity should be maintained at 60-70% (maximum 75%) once the egg has internally pipped to prevent the membranes from drying.
- Grey non-slip matting must always be placed on top of the metal tray in a still air or on the base of the hatcher tray in the forced draft system. It must cover the entire base. The matting should also be as secure as possible so that no movement of the matting can occur once the chick has emerged from the egg. This provides important traction to both the egg and chick once it has hatched and prevents the chick injuring its bill or toes on the metal base tray.

- The metal rods used as support during incubation in the still air should not to be used during hatching. In general, egg stabilisation should not be necessary, but if required, the egg can be supported using wads of Vetwrap™ (or something similar) on either side of the egg, similar to a chock, to provide some resistance when the chick is hatching. Do not use cotton wool.
- All hatching eggs need be observed four times per day (with an absolute minimum requirement of two observations), and all hatch information recorded in detail. Eggs can be briefly candled twice per day (morning and evening), and chick movements visually checked. Problem eggs may need to be checked more regularly. If the hatch is progressing well, no assistance should be necessary.
- All holes in the still air hatcher lid and base must be left open for appropriate air circulation.
- Record detailed notes throughout the hatching process.
- If the external pip is unusual, sketch the cracking pattern in the hatch notes. Information transfer is important to make sure other staff members can correctly monitor changes in the hatch as it progresses.



Figures 13 and 14. Examples of External pip (Photos: National Kiwi Hatchery and Claire Travers)

11.1.2 Initiation of Hatching

The initiation of hatching can vary with each individual egg.

Drawdown

Care should be taken to ensure drawdown is detected. When an egg starts going into drawdown, this is an excellent indicator that the hatch process is well on its way. At this stage the chick should have almost fully rotated into the correct hatching position, or if a malposition is suspected then now is the time to accurately detect this (see appendix for information on malpositions).

- An indication of drawdown is a rapid large increase in air cell size and the development of a 'shelf' around the back of the air cell (right hand side when the egg is held correctly, and the air cell is away from you).
- The region under the air cell (at the back of the egg) becomes extremely dark (black). The narrow light band or glow around the air cell has disappeared as a result of the embryo having rotated into the hatch position and is pushing against the shell.
- There are very thick, dark veins evident on the top of the egg just below the air cell line.
- The body of the egg looks extremely dark when candled, especially on the top and lateral sides. There is a dark red glow of yolk at the non-air cell end of the egg, and waste deposits are difficult to identify.
- Embryonic movement may slow a little prior to internal pip, and this needs to be carefully monitored. Hatching is an extremely physiologically demanding event and embryos do go through 'resting' periods during the hatching process.
- As the embryo prepares for internal pip there develops a "pre-internal pip glow" across the upper surface of the egg.
- These characteristics are all pre-internal pip and make up the definition of drawdown. It is important to note that drawdown may occur between weigh days and observations at this stage should be detailed.

Internal pip

Once drawdown has been recorded, internal pip (IP) generally occurs within the next few days (usually 4-5 days before hatching). The sequence is briefly outlined below but the time intervals will vary between individual chicks.

Internal pip is essentially evident by an obvious lightening in the central top area of the shell as the top of the egg is candled. It is usual to see the bill, but not always. The egg cannot lighten on top without pulmonary respiration commencing (and in some instances this may take up to 12 hours after internal pip).

- As soon as internal pip has been detected, clearly record this on the egg data notes and write IP on the air cell of the egg in pencil.
- At this stage the egg needs careful monitoring with a brief candle at least once per day.

- Occasionally it is possible to feel vibrations in the egg as it is held (due to the chick vocalising within the egg), but the vocalisations are not necessarily audible at this stage.
- It may not always be possible to see the bill directly up against the shell, but when the bill is there, it is usually obvious. If you don't see the tip of the bill directly, angle the candler around the air cell to detect the shadow made by the bill.
- Throughout the internal pip process, it is important to remember that the position and the angle of the bill can change as the chick continues to rotate into the correct hatch position. The bill may even recede under the chorioallantoic membrane giving a 'tenting' impression when candled.
- If the candler is held steady at the air cell it is possible to see good bill movements under the shell or embryonic movements of the egg when it is placed on the bench. These can be amplified by whistling or lightly tapping the bench nest to the egg.
- Prior to external pip the egg can lighten considerably in colour. Initially the egg should appear very dark on the left-hand lateral side, and quite red orange through the main body of the egg, with a strong vein network still evident. The non-air cell end (NACE) of the egg should still appear as a dark, intense red-orange colour.
- At this stage the hock can often be detected on the lower left-hand side of the egg. If it is on the right-hand side, the chick is potentially malpositioned, you may also see leg, foot or toe movements visible under the shell during candling.
- Not all eggs have externally pipped 3-4 days out from the initiation of hatching, and some eggs look considerably more 'yolky' (golden) in general appearance. This is quite normal.

External pip

The definition of external pip (XP) is where the shell is cracked by the pressure of the bill pushing outwards on the inside of the eggshell. At this stage, eggs must be transferred into a dedicated hatching incubator, if this has not already happened. Once the first sign of external pip is confirmed, clearly record this on the incubation notes.

- By this stage the bill is often pushed up against the inside of the shell.
- There is a strong vascular network still visible on the top surface of the egg, often with a few prominent veins.
- There is a definite lightening in the red-orange colour (glow) through the main body of the egg, and the non-air cell end is still a fairly yellow glow.
- The red-orange colour will then start to change to a more orange colour. This progresses to an orange-yellow colour without any change in the appearance of the shell and is quite normal.
- If weight loss had been too high during incubation and it had been necessary to tape the egg, remove some of this tape so it does not interfere with the hatching process.

- Frequent observations are important at this time. It is best practice to candle the egg both in the morning and in the evening, with quick visual checks during the day. In some eggs the veins appear less defined, and it is important to consider the overall appearance of the egg when candling, including movement and vocalisations.
- It is essential to write clear detailed notes of the appearance of the egg and activity of the chick during hatching. It can be useful to make a quick sketch of the initial external pip, and any other major changes to help with information transfer between incubation staff.
- Once the shell is cracked and shell flaps are lifting with the pressure from the bill tip, it is important to smell inside the egg. You do not need to touch the egg with your nose, but this 'sniff' test enables detection of wet and sweaty chicks, which is an indication of a difficult hatch and chicks possibly becoming stressed, especially in a long hatch.

11.1.3 Low or Unusual Internal and External Pips

Low lying or unusual internal and external pips occur when the chick both internally and externally pips at the same time, low on the edge of the air cell (usually on the left-hand side). This is a result of the chick not rotating around far enough into the normal hatch position.

Provided the chick has access to air (i.e., it has successfully internally pipped into the air cell), and the egg is beginning to clear out, the egg only needs monitoring. Very occasionally it may be necessary to 'artificially' internally pip the egg at this external pip site to ensure adequate oxygen is available to the chick. (Refer to Appendix 1.1 for further information).

11.1.4 Providing Lateral Cracks during Hatching

If the egg has completely cleared out, looks ready for hatch but the hatch appears to have stopped for 12 hours and there is a strong wet 'sweaty' smell, it is appropriate to be pro-active by making two lateral cracks radiating out from either side of the external pip site (~2 cm). These small cracks should encourage more movement from the chick and consequently make the final part of the hatch easier. If there has been no change or advancement in the hatch, it may be necessary to extend these cracks further down the sides (~5 cm). This can often be done just by flexing the shell a little to extend the cracks.

Occasionally during hatching the chick will force one or both hocks out of the blunt end of the shell. Once extensive cracking is evident at the non-air cell end of the egg, tape a small pad of gauze over this area to prevent the hock going right through the shell (Figure 15). It is important that the pad is large enough to cover both hock areas. If the leg is forced out it will make the rest of the hatch difficult as the chick cannot brace its legs correctly against the shell, to push out the top of the air cell end.

Figures 15 and 16. A kiwi chick in the process of pushing its hock through the non-air cell end of shell. The second photo the hole has been covered to assist the hatch. (Photo National Kiwi Hatchery).

Note

A small number of hatches will have problems, including malpositions and external yolks or umbilici. These eggs will require assistance if they are to hatch successfully. Procedures that may be required include artificial external and internal pip and x-rays. Details of these procedures are given in Appendix 1. Veterinary assistance may be required.

It is imperative not to assist in the hatch unnecessarily as the chick needs time to internalise all yolk before hatching, but it is important to assist if the chick becomes very weak or stressed (refer to Appendix 1.3).

Minimum Standard 9.
Monitoring kiwi eggs during the hatching process

a) Each egg should be placed in an appropriate incubator, hatcher, or hatch tray compartment on its' own, and allowed to hatch as naturally as possible.

b) All incubation parameters must be followed and recorded at least twice per day for each egg.

c) Each kiwi egg in the process of hatching should be monitored at least twice per day to assess hatch progress.

d) Accurate daily hatch records must be kept for each individual kiwi egg.

e) Careful consideration should be given before any hatching assistance is undertaken, but if deemed necessary hatching assistance should be provided.

f) All staff must have achieved accreditation in the hatching processes (or be in the process of being trained) and are registered in the Department of Conservation data base as a Kiwi Accredited Handler.

11.2 Immediate Post Hatch Care of all Chicks

- As soon as the chick has hatched, observe the appearance of the navel. A slightly open navel or a 'donut' appearance does not require any further attention. It is important to leave the chick for 10 minutes to rest after hatching, and to allow the navel to close.
- Once the chick has hatched and rested, the egg shell, membranes and hatch remains can be removed. It is vital to ensure that the umbilical veins and artery (usually still attached to the shell/residual chorioallantoic membrane) are completely separated from the chick before any shell is removed. This is a critical time to avoid any sort of infection, so surgical gloves must be worn.
- Weigh the chick, ensuring that every care is taken to fully support the chick, especially the abdomen (Figure 17).

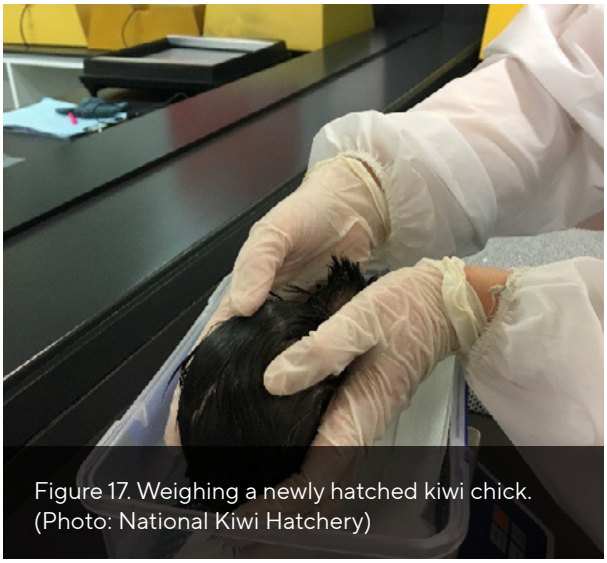


Figure 17. Weighing a newly hatched kiwi chick. (Photo: National Kiwi Hatchery)

- Carefully check the navel and if normal, spray navel with Betadine solution. Check there is no sign of an external yolk, hernia, or an unformed umbilicus. If the navel is slightly open, use Betadine cream rather than spray.
- Check that the legs, toes, and bill tip (in case of bruising) all appear normal.
- If the still air hatcher is to be used for brooding the chick, empty the water trays and remove all eggs shell and waste, then add clean matting, before returning the chick.
- All chicks are considered to be day zero on the actual day of hatch. If the chick hatched overnight and is completely dry and fluffy in the morning, consider it to have hatched on the previous day and record the date and age accordingly.
- Once the chick is dry start to gradually lower the hatcher temperature a few hours after the hatch is complete. Regularly monitor the chick's behaviour to make sure it is not consistently shivering (this does not include intermittent shaking). If the chick is observed consistently shivering raise the temperature again slightly until the behaviour improves and the chick is thermo-regulating correctly. Gradually continue to lower the hatcher temperature until the chick is moved into the brooder.
- If the chick is moving into a Brinsea TLC unit, make sure that the unit is at a stable temperature of 34°C. The chick may remain in the hatching incubator for the first 8 hours to fluff up, if necessary, before being transferred to the TLC unit.
- Check the chick regularly during the day and monitor its body position. Record if chick is lying on its side, crouching, etc. Occasionally it may be necessary to place the chick into a 'donut' support if it is cast on one side and does not appear to be able to crouch properly (Figure 17). Donuts can be easily constructed using

paper towels, towels or grey matting wrapped around to form a firm donut shape large enough to contain the chick. It is important not to leave the chick in the donut overnight, though it can be used again the following day if the chick is still struggling to crouch.

- Once the chick has hatched, it is important for the bird's leg development that the substrate of the hatcher and then the brooder allows sufficient traction. Matting should always be used in the small sleeping area of the brooder for the first 6 days after hatch. If the chick does have leg problems, then matting should be used throughout the brooder instead of peat moss. Failure to provide the appropriate substrate is a leading cause of splayed legs in kiwi chicks.

Figure 18 and 19. Use of a paper towel donut or matting donut to stabilise a kiwi chick. (Photos: National Kiwi Hatchery).

Minimum Standard 10.
Initial post hatch care of kiwi chicks

a) Weigh the chick once it has hatched. Observe the appearance of the navel and apply Betadine spray or cream. Carry out a brief health check to see the bill, legs and toes are normal.

b) If the hatcher is to be used to brood the chick post hatch, remove all egg shell and membranes, and remove all water from the trays before the chick is returned.

c) Maintain appropriate post hatch temperature conditions including a gradual reduction in hatcher temperature until the chick is moved into a brooder.

d) Always use matting in the hatcher and matting in the small sleeping area of the brooder for the first 6 days to prevent splayed leg problems.

e) Observe the chick at least twice daily.

f) Ensure the chick is clearly identified and keep all egg and hatch records with the correct chick

11.3 Post Hatch Care of Assisted Hatch Chicks (including malpositioned chicks)

The degree of malposition at hatch will determine how a chick is cared for in the hatcher. A chick that required minimal assistance is then treated as a normally hatched chick.

A chick that requires full assistance out of the shell, with a normal presentation, needs to be closely monitored for correct thermo-regulation post hatch. Often these chicks internally and externally pip but for some reason fail to continue with the hatch process (especially if it has been prolonged and the chick is tired). Care and careful observations will be required as the hatcher temperature is being reduced.

Severely malpositioned chicks require extremely detailed observation especially regarding leg position and angle, and navel issues. Often as a result of the position in the shell they have been unable to internalise all of the yolk, which coincides with a reduced ability to crouch at an early stage. It is critical that this is identified as early as possible. Chicks need to be placed in a donut (see definition above) if they are continually rolling on their side and becoming cast. If left too long in this position fluid can build up in both the lungs and the air sacs. This is most obvious in chicks with a hugely distended yolk-filled abdomen.

On very rare occasions kiwi chicks are affected with splayed or rotated legs. This may be a result of an unusual position in the egg, a fall resulting in injury to the leg, or slipping on a smooth surface in the hatcher/brooder. Splayed legs are preventable by the use of non-slip brooder matting and can be corrected with hobbles/spacers, if identified early enough. Details of hobbling are given in Appendix 2.

Seek veterinary assistance if a chick has hatched with splayed or rotated limbs, or any other physical deformities.

11.4 Extended Time in the Hatcher/Brooder

In some situations (i.e., malpositioned chicks and prolonged hatches) a chick may remain in the incubator/hatcher for an additional day as the temperature is reduced at a slower rate based on its behaviour. It is desirable to get chicks into an ambient (approx. 25°C) brooder within three days (four days in extreme circumstances only). It is important that the temperature in the hatcher/brooder is not increased above 34°C and it must be closely monitored. Any chick that remains in a hatcher at too high a temperature will get dehydrated extremely quickly, which can lead to serious health problems later on.

Minimum Standard 11.
Monitoring problem hatch chicks

a) Seek immediate veterinary assistance in regard to chicks which have hatched with major deformities or severely splayed or rotated limbs.

b) Provide appropriate treatment to any chick with minor leg problems.

c) Provide all necessary post-hatch care required and monitor the chick at least twice daily.

d) Accurately record all post-hatch treatment undertaken, and document with photographs if appropriate.

e) Maintain appropriate post hatch temperature conditions for the chick.

f) Review egg and chick management practices to determine the cause of the problem encountered and identify future prevention methods to be taken.

12. Hatched Chick Care in the Brooder Room

Over the years that ONE has been used there has been a variety of methods developed for caring for and rearing kiwi chicks post hatch. The systems below are the ones that have been shown to cover the health and welfare requirements of the chick most effectively while being efficient to manage.

This section relates to chick care and husbandry once hatching is completed.

Performance Standard 2.
Post-hatch chick survival

a) 85% of all successfully hatched ONE chicks should survive to release.

b) All chicks that die are sent for independent post-mortem examination to determine cause of death.

12.1 Initial Post Hatch Care

Kiwi Chicks tend to stay in a post hatch brooder care for 2 to 4 days after hatch. These post hatch brooders can either be a still air hatcher, that is then used as a brooder, a Brinsea TLC brooder or a forced draft hatcher.

- Weigh the chick each morning, record the weight (to the nearest 0.1gram) and plot this on the chick's weight graph data sheet.
- Note the chicks' general behaviour and position (fluffed up, awake, crouching, sleeping etc), note the orientation of the legs too. Spray the navel with Betadine.
- Place clean brooder matting on the base of the incubator if it is soiled. Ensure that any rubber matting is secured into position at each end to prevent any movement.
- If the chick is in a TLC brooder, a rolled-up towel or matting around the edge can be used for the chick to nestle into.
- Observe the appearance of the faeces. Normal faeces should be cream through to green in colour, with a yellow urate component, for the first three to five days and then changes to a usual Kiwi faecal appearance.
- Within the first 24 hours after hatching the temperature should be reduced to 30 to 32°C, and the chick may be moved into a TLC brooder (if used). If the chick is transferred to a TLC unit (once the chick is dry), further reduce the temperature over the next 48 hours at a rate determined by the chicks' behaviour, until the chick is comfortable at 24 to 27°C.

NB: Great Spotted Kiwi chicks require a faster reduction in hatcher temperature post hatch when compared with other species of kiwi chick, 20 to 22°C by the end of day three.

- On the second to fourth day, depending on the system used post hatch (TLC), the chick should be ready to transfer to a large brooder, in the dedicated 'brooder room'. The room temperature should be 20 to 24 °C. This temperature should be constant for the duration of the chicks stay indoors in the brooder room. Chicks that are kept too warm are generally lethargic and very slow to start eating naturally.
- Chicks are only to stay in the post hatch brooder for longer than 2 to 4 days if the hatch has been difficult and the chick needs more observations. They must be monitored closely, but continue to reduce the temperature down, slowly but watching for any signs of constantly shivering, which indicates it is too cold.
- Day two is the same as the above, but the chick should be moved into the brooder room by the end of the second day.

12.2 Chick Care in the Brooder Room

Brooder rooms should be maintained at a constant ambient temperature of 20°C, with good ventilation and windows so the chicks can naturally develop their nocturnal behaviour.

Good hygiene practices within the brooder room are essential. Prior to the season starting the brooder room is to be thoroughly cleaned with Sterigene 1% solution (1:100 dilution rate) or Microshield (Chlorhexidine) 4% solution, including the ceiling, walls, floors, and all equipment used in the room.

The brooder room should then be cleaned weekly, with the floors being swept and mopped daily. Dedicated ONE shoes and lab coats should be provided and used in the brooder room. Hands are to be thoroughly washed, dried, and sanitised before handling kiwi chicks, kiwi food or equipment. Remembering to sanitise regularly between handling chicks and equipment.

There are many different styles of brooder in use but they all must be safe, with smooth, washable surfaces, and no ledges, screws, or nails protruding. In general brooders should be 70 cm wide x 165 cm long. They must include a smaller sleeping area or separate box (that can be removed for cleaning purposes). This sleeping box needs to be large enough to allow a heat plate to be placed inside to brood the chick for the first few days and have a lid for accessing the chick easily. There should be a small door (15 cm x 20 cm) into the sleeping area too. Brooders are much easier to clean if they are raised off the ground by approximately 50 cm, and the total height to the top of the brooder should be about 95 cm.

If 'rubber flaps' are used in the outside pens on the feed boxes and tunnels (to reduce diurnal birds from entering the boxes to steal the kiwi food), the brooder room is a good time to start introducing the flap system to acclimatise the young chicks in using them. One small flap is 'velcroed' to the entrance of the sleeping area and once the chick has established good nocturnal habits then the second overlapping 'flap' can be attached. The chick then becomes used to pushing through the flaps to enter and exit areas and this behaviour can easily be transferred to entering the food boxes.

12.2.1 Setting up the Brooder.

- There are a variety of brooder designs currently in use for rearing Operation Nest Egg kiwi primarily made with ply wood that is sealed with a gel coat to allow for cleaning or fibre glass. See below for examples (Figures 19 and 20).
- The brooder must be cleaned, prepared and the heat lamp temperature set (if a heat source is used) before the chick is to be moved from the hatcher.
- A brooder can be prepared for a chick in two different ways:
    - Both the sleeping area and main area can be lined initially with non-slip matting or towelling as an alternative to peat moss. Once they are well established on the artificial diet then the matting can be replaced with peat moss with no ill effects. It was found that if peat moss were used immediately a percentage of chicks would ingest the soil material in preference to the food.
    - A 'soil' brooder should be filled with dampened peat moss (i.e., Yates) to a depth of 6cm. Dampened peat moss should feel crumbly when touched. Not dusty or sodden.
    - A layer of soft native vegetation can be placed over both types of substrate, only in the larger area. Examples being, Kawakawa (Piper excelsum), Fern fronds, Kapuka (Griselinia sp.) Lemonwood etc. for behavioural enrichment. If using fern fronds, ensure they have not got any sporangia on the underside of the fern that produces the dusty spores.
- If an external heat source or heat plate is used inside the sleeping box, set the temperature to provide approximately 26 to 28°C, at chick height. Make sure a temperature sensor is attached to each brooder and set at chick height.
- If using peat moss, then it is advisable that only individual small garden forks, specific to each brooder, must be used to dig over the soil.
- Supply fresh water in a shallow dish and place in the large area of the brooder.

Figure 20 Example of brooder boxes made with Plywood, the inside has a gel coat, and a built-in sleeping area. (Photo: National Kiwi Hatchery).

Figure 21 Fibre glass brooder with lid raised, the sleeping box can be placed anywhere within the brooder. (Photo: Gallagher Kiwi Burrow)

12.2.2 Chick Transfer to Brooder (approximately 48 hours post-hatch)

When caring for kiwi chicks, consider that every chick is an individual and the processes used for one might need altering slightly with another to allow for that individuality. A holistic approach to chick care is essential. Ideally chicks should be moved from the hatcher at 48 hours post-hatch, and into a brooder unit. This interval can be extended to four days if chicks are transferred to a TLC brooder unit after hatching.

- If possible, only one chick should be placed into a single brooder, however this is not always feasible with space and the number of brooders available. In this situation it is strongly advised a maximum of two chicks only are placed in a brooder.
- When putting two chicks into one brooder, it is essential that both chicks are wearing a different coloured leg band for identification purposes. It is important not to have any chick identity mix-ups. Record the colour of the band on the chick's notes. The leg band must be checked regularly and replaced when required as the chick grows. Small temporary plastic leg bands can easily be purchased from the DOC banding office or made on site using coloured electrical tape.
- Both chicks should be of similar size and age, and placed into the brooder from the hatch room at the same time as this will minimise any potential dominance behaviour ('bullying').
- Record any individual distinguishing marks found on the chicks to help identify them (e.g., white feathers on head, toe nail colours, very dark/light feathers).
- Record the brooder number in the chick notes so there can be no mix ups regarding where the chick is located. Keep the chick notes with that brooder.
- If the walls allow it (white board type material) record the Chick ID and the hatch date on the wall by that brooder. Include any other relevant information.
- Place the chick in the sleeping area, on clean grey matting with a heat plate or lamp. Do not use hay or straw as bedding material due to the risk associated with either Aspergillus species.
- Begin an individual chick weight graph for each chick as soon as they hatch. Clearly mark the weight corresponding to a 25% and 30% weight loss as a proportion of hatch weight. There is debate about how much weight is safe for a chick to lose post hatch as some species vary but it is recommended that:
    - Brown kiwi and Rowi lose no more than 25% of their hatch weight as best practise.
    - Haast Tokoeka can lose between 25% to 30% of their hatch weight.
    - Great Spotted Kiwi chicks can lose up to 35% before intervention.
- It is essential that the chick is checked twice per day (morning and evening) and if an external heat source is used, it is important to monitor the chicks' behaviour (correct thermo-regulation) in relation to the reduction in brooder temperature. Also, to keep a close eye on activity (record probing activity, faeces - number and type, footprints, dirty water etc). If night cameras are used check the video footage.

- Chicks in the brooder room should be weighed daily, preferably at the same time each day, by placing them in a covered box or container and using electronic scales weighed to the nearest 1 gram. A bucket or large plastic container with a lid and a non-slip matting base are perfect. It is important to ensure the chick cannot jump out of the weigh box, and that nonslip matting is used to prevent the bird from skidding.
- The navel area needs monitoring, and the navel should be sprayed with Betadine once a day until the chick is three to five days old. Discretion is required as a chick that has had a difficult hatch or an external yolk will need more care for a longer period of time to prevent possible infection.
- Replace grey matting/bedding each day or when soiled. The matting will need to have faeces scrubbed off in hot water, then soaked in Sterigene and/or Napisan and washed in the washing machine.
- Check faeces to see if they are a normal greenish, yolky colour*; check the chick's eyes; and make a note of the chick's behaviour (i.e., standing, sleeping, walking, shivering, alert, etc).

*Note: if a young chick is on the antibiotic 'Clavulox' the faeces may appear quite pink/orange.

12.2.3 Day 3 and Day 4

- Weigh chick and accurately record all information on the relevant record. Consider that initial weight loss will vary for each chick and will depend on factors like chick weight, brooder temperature, level of activity, normal vs. difficult hatch, even yolk quality will have an impact. So average weight loss at this age is 8-12 grams per night in young chicks but be prepared for variables.
    - Great Spotted kiwi chicks can lose 15g and over in the first night and regularly lose 8-12g over the next 4-5 days.
- This degree of weight loss should lessen over the next few days and by day eight chicks should only be losing about 2-3 grams per night, on average.
- Continue to check the navel daily.
- There should now be signs of the chick moving about. Check for probe holes around the edge of the matting and replace with clean matting when necessary. Observe if the chick has emerged out into the entrance of the large section of the brooder, make a note of the movement area.
- If used, gradually reduce the temperature of the heat lamp. The temperature of a heat plate cannot be adjusted.
- Check the abdomen, eyes, plumage, general condition, and behaviour each day when a chick is weighed.
- If a chick has been held in a TLC brooder it should be transferred to the allocated brooder at ambient room temperature on day four, (note this is dependent on chick behaviour, but the transfer should be undertaken within five days).

12.2.4 Day 5 - Full Health Check

- Weigh the chick and plot on the weight chart.
- By now the chick should be out each night in the large part of the brooder. Signs of activity include probe holes and dirtied water (this is harder to determine with birds kept on matting, but usually there is evidence that a chick has been utilising the water dish or probe holes in the leaf litter). Note the presence and condition of faeces in the large area. Continue to reduce the temperature of the heat lamp down to ambient room temperature if you are able.
- Undertake a full health check. This involves checking the eyes (are they clear and bright or can you see a foreign body, either a small piece of shell from hatch or feather sheaths) ears, nostrils (redness, presence of any mucus or discharge). The colour of the gape (a pink colour is normal, very pale, or very red in colour is not), hips, legs, and feet (any sign of heat, swelling, splaying or signs of dehydration), the spine (prominent vertebrae and ribs), and the abdomen. Closely observe the navel for swelling or tightness, and the navel stalk for redness or discolouration or discharge (do not squeeze the navel), check the cloaca for 'dag-like' faeces or any unusual discharge. A full description of a comprehensive health check for kiwi can be found in Kiwi First Aid and Veterinary Care (Morgan 2008).
- Changes in the appearance of the abdomen in young chicks over the first five days:
    - Very 'yolky' when first hatched, (abdomen full, distended). Care must be taken when handling these young chicks, use the 'basket hold' when carrying them.
    - Two to four days later the abdomen can still be soft and pliable but should be less distended (smaller).
    - Generally, the soft 'yolky' feel changes to a firmer and gently rounded abdomen by day five. It is important to feel above and below the umbilicus, and to gently check the entire navel area.
    - The abdomen should then begin to level as the yolk is utilised. Note that some chicks can have a very soft yolky abdomen but still move straight onto eating the artificial diet themselves.
    - From flat and empty, the abdomen can move to feeling concave. This can correspond with a chick that had a small hatch weight, they can have a prominent spine and bony hips. Chicks in this condition need to be carefully managed and assess the need for liquid supplement.
    - If pus is apparent on the umbilicus, it is essential to contact your veterinarian and start the chick on a course of antibiotics.
    - If the chick is just getting onto food, the abdomen will feel firmer (and occasionally even lumpy) above the umbilicus and often softer below the umbilicus (caudal area). Remember this all changes on an individual basis, do not be rigid in your assessment, e.g., a 10-day old individual can still have a gently rounded yolky feeling abdomen.

- Place the chick down in the cleaned brooder, outside the sleeping area and watch the chick walk. Note behaviour such as shuffling as opposed to walking, limping, early signs of splayed legs etc. Record general chick behaviour, characteristics, and alertness.
- 10 grams of food can be put out into the large part of the brooder (near the entrance) on the night of day five, depending on the chick's yolk absorption. By now there should be high levels of overnight activity, flatter abdomens, and active probing behaviour.

  If the chick still has a soft rounded belly during gentle palpation, food could be held off until night six or seven. Make note that if a small chick has utilised it's yolk very quickly and is obviously thin (possibly showing signs of dehydration) then liquid supplement in the form of a slurry made from Hill's Prescription Diet a/d mix, can be given, to reduce the risk of too rapid a weight loss.

  - For GSK's, food introduction is better done from day 8 – 10 depending on the individual, deciding factors are daily weight loss (down to around 2g/day), chick activity and feel of the stomach.
  - For the Rowi and Haast Tokoeka it is common to see diurnal activity in younger chicks. So currently 10g food is also offered on night 5, which has resulted in chicks eating food earlier and reduced diurnal activity.

12.2.5 Day 6

- Signs of activity should continue to be seen in the large section of the brooder.
- By day six the sleeping area should be around room temperature, if an external heat source is being used it should be turned off if a heat plate was used it can be removed.
- The sleeping box should contain a substrate that can be easy changed, allowing easy cleaning (e.g., green fern fronds, or non-slip rubber matting). If soil is used in the brooder, check that the soil is still damp, remove faeces and dig over.
- The chick's weight should be recorded in the morning and the abdomen very gently palpated to make sure the yolk is being absorbed.

Minimum Standard 12.
Post hatch care of chicks in the first week of life

a) Weigh the chick daily and monitor weight patterns on a growth chart

b) Transfer the chick from an incubator to a brooder within 2-3 days or from a TLC unit within 4 days of hatching.

c) Place the chick in a clean, safe, secure brooder containing a darkened sleeping area, suitable substrate, and clean water.

d) Ensure the brooder number is recorded in the chick's notes.

e) If two chicks are to be placed in the same brooder, apply a temporary leg band to each chick and clearly note this on the chick records.

f) If using peat moss, ensure that the brooder is dug over and maintained at the correct moisture level.

g) If using native leaf litter in the brooder ensure that it is replenished and refreshed regularly

h) Ensure that fresh water is provided daily.

i) Carry out a full health examination of the chick at 5 days of age.

j) Keep the brooders and brooder room clean at all times.

12.3 Feeding Chicks

There is now an ongoing diet trial aiming at standardising the diet fed to kiwi throughout all facilities across New Zealand. The main components consist of meat (a mix of beef steak mince and ox-heart), fruit and vegetables, and various other ingredients including kiwi premix. This was introduced in 2016 and while it was an improvement on the various diets that were being used, there are still refinements being implemented with assistance from Massey University's vet and ecology departments. Guidelines are given in the Brown Kiwi Husbandry Manual (Fraser & Johnston 2015).

12.3.1 Introduction to Feeding

Throughout the duration of using ONE for rearing chicks it has been found that there are many factors that influence the decision of when it is best to put out the food for the first time e.g., species, age, substrate, yolk absorption rate, behaviour. Each chick will need to be evaluated on a case-by-case basis when starting to introduce the artificial diet.

All chicks should be fed the same artificial diet as captive adult kiwi held at the captive institute, but it should be cut into smaller pieces when it is first introduced, especially the beef heart. It is not necessary to separate out the individual components, as it is important that the chick learns to consume the complete artificial diet. It is very important that the chick's abdomen and faecal output should be monitored for absorption of the yolk. By the time the chick is due to be

introduced onto food (between 5-10 days) the belly should not be distended, and the faecal colour should be normal (not too 'yolky').

- In general, food should be introduced to a Brown Kiwi chick from day 5, especially if the chick is tracking along the average weight loss and behaviour is considered to be normal. But if the chick is extremely active and has utilised its yolk early then there is the possibility of using a fluid supplement (Hill's Prescription Diet a/d mix) to reduce any risk of dehydration – again case by case basis.
    - Both Rowi and Haast Tokoeka will have the food put out on the night of day five
    - Great Spotted Kiwi will not require the food putting out until at least day 8-10
- All chicks will lose weight after hatching over the first 7-12 days as their yolk is being utilised. Chicks can lose from 20% up to 35% of hatch weight in the first 10-15 days again depending on the species.

12.3.2 General Feeding Information

- Always provide fresh water in a large shallow dish.
- Supply fresh food overnight, every night. Ensure that initially small flat dishes are used for easy access and that they are well anchored in to the soil or to the surface of the brooder, so they cannot be tipped over.
- During the first week of feeding, the dish can be placed in the large area close to the entrance to the sleeping area so the chick can easily locate the food without having to venture too far into the large area.
- Record daily the amount of food fed out AND the amount of food eaten overnight. Starting with 10 grams.
- All old food must be collected from the brooder daily (and it may be well buried and flicked around). Old food needs to have any brooder substrate removed before weighing. Record if the food is untouched, or played with but not eaten, etc.
- Wipe the sides of the brooder to remove any moisture, dirt, and old food.
- Record general behaviour (i.e., messy eater or calm when handled), monitor and investigate any unusual chick behaviour. Monitor faecals etc.
- Gradually increase the amount of food offered overnight, especially when chicks are establishing a regular feeding regime, use several dishes if needed, dotted about the brooder. As a general rule, based on what amount has been eaten the night before, increase the amount of food given by 10 grams per night, up until a consumption rate of 50 grams/night is achieved. From this point, increase the amount given by 20 grams per night.
- But be aware that if you get too rapid a weight gain (over 15g per day regularly) the food amount given will need capping as rapid weight gain can be detrimental to the chick and can cause leg issues later (tibiotarsal rotation).
- Be careful not to offer too much food too quickly. Occasionally chicks will gorge and then stop eating and become a problem chick.

Observation of the weigh growth chart is critical. The 25% for Brown kiwi and Rowi, up to 30% for Haast and 35% weight loss line for Great Spotted Kiwi must be accurately drawn on the graph. When the respective chick's weight falls close to this percentage weight loss threshold, then intervention is required. If the chicks weight falls below this line the chick will start utilising its own muscle mass which in turn disrupts the metabolic system and can lead to serious health repercussions with veterinary assistance being required. It is essential to use assisted feeding to increase the bird's weight above this amount.

12.3.3 Assisted Feeding of Kiwi Chicks

Whether feeding assistance is necessary is highly dependent on each individual kiwi chick, its rate of yolk utilisation (detected by gently palpating its stomach for the presence of yolk), it's weight loss percentage and its levels of activity. The vast majority of kiwi chicks will begin to eat unassisted in seven to ten days of hatching and will require no help. But it is important that chicks do not lose excessive amounts of weight as mentioned above. If the weight loss starts tracking close to the lower weight loss percentage. There are two options that can be used, a fluid nutritional supplement (Hill's Prescription Diet a/d mix) or small pieces of the artificial diet can be hand fed to the chick – initially just a couple of grams (which equates to about 2 to 4 small pieces). This will start the turnaround of the weight loss and usually the chick establishes on the artificial diet shortly after that.

An important but simple way to monitor this weight loss (and subsequent rate of growth) is by using a weight graph. This allows for quick and easy visual identification of a chick's progress and accurate monitoring of the rate of growth.

Outlined below is the current feeding regime undertaken on Brown kiwi chicks at the National Kiwi Hatchery, this system has been developed over the 20 years that ONE has been used at there.

Assisting a chick to feed should only be undertaken after careful consideration of the chicks' degree of weight loss, yolk presence and size and the age of the chick.

From day nine: 2 to 4 small pieces of ox-heart (2 grams) can be offered to the chick as an introductory taste only. This needs to be done quietly and with as little stress as possible. Usually, the chick will start playing with the food and probing your fingers (refer to Figure 21).

- It is important to be calm, quiet, and patient when feeding kiwi chicks. It needs to be a positive experience.
- If experienced, one person can start the food introduction to a chick. But two people can do this too.
- Sit the chick on a towel on your lap, with a small flat dish of food and see if the chick shows any interest in the food. Gently rub the meat near the tip of the bill, this can stimulate them to try to pick at the meat. Gently place the meat in the tip and see if the chick tries to manipulate the food so it can swallow it. If there is no attempt at grabbing the meat, the piece can be slowly moved up to mid bill,

base of bill and then over the tongue. Make sure the chick remains as calm as possible and that the introductory feed is gentle, quiet, and short.

- If the chick has shown good interest in the food, then put the chick and the food back into the brooder. Good interest usually means they will self-feed very soon.
- Day food should be added from this point on (10 grams only) and placed in the small sleeping section of the brooder. The day food must be removed during the early afternoon check, weighed, and recorded. At this stage chicks should only be losing 3-4 grams/night.

Figure 22. Assisted feeding of artificial diet to a young kiwi chick. (Photo: National Kiwi Hatchery)

12.3.4 Assist Feeding Problem Chicks

Sometimes it is extremely difficult to assist feed a very 'wriggly' chick. This causes stress for the holder, the feeder, and the chick, and needs to be minimised if possible. If the chick is wriggling too much, is showing no interest in the food at all and is literally 'shutting down' then you must place the chick back into the sleeping area of the brooder for at least 30 mins while you wait for the chick to calm down. If this happens you have two options, opt for the highly nutritious liquid feed, or try again with the food pieces after the chick has managed to calm down.

Please do not hesitate to contact other facilities that raise kiwi chicks to ask for advice or assistance when a chick needs some assistance.

12.3.5 Feeding Two Chicks Sharing a Single Brooder

On occasions, two chicks may need to be placed into one brooder. Remember that both chicks must always be banded.

- All brooder care and feeding is the same for both chicks, but you need to make sure that double the amount of food is put out into two food bowls spaced apart from each other.
- It is important to correctly identify each chick before weighing and entering chick weights. It is essential not to have identity mix-ups, and it may be necessary to re-band a chick if the band is wearing off.
- Sometimes one chick will establish themselves on the food, and the other sharing the brooder will not (dominance behaviour from the brooder mate or lack of interest in food). Carefully assess the weight gains between both chicks, and correctly identify who is eating, and who is not. Often this can be managed by assist feeding one chick and allowing the second chick to feed independently.

- If dominance behaviour is evident (one chick out during the day, or evidence of growling and fighting in the sleeping box) it will be necessary to separate the two chicks. Ideally, the chick doing well should be moved into another brooder, although brooder space can at times be limited. If there is no spare brooder, it is possible to place a divider down the length of the brooder to separate the two chicks.
- Carefully monitor the chicks after any move. They may take a few days to settle into their new brooder, attention to food consumption and weight changes are required.

Minimum Standard 13.
Establishing kiwi chicks onto the artificial diet and monitoring growth

a) All chicks must be weighed daily, and all weights recorded on a growth chart.

b) Ensure that the brooder is kept clean (remove old food and faeces) and fresh food and water are provided daily.

c) Depending on the species of chick, if it reaches the lower level of its hatch weight percentage then assisted feeding must commence.

d) If the chick reaches critical weight loss, veterinary assistance must be sought.

e) All food presented to the chick must be weighed and the amount consumed overnight recorded

12.3.6 Chicks Feeding Independently

Once a chick is established on the captive kiwi diet and is eating independently it is still important to monitor food consumption on a daily basis. All daily weight gains and amounts of food eaten should be recorded, and the amount of new food provided each evening reassessed daily.

12.3.7 Regular Health Checks for Kiwi in Brooder Care

Once a chick has established good eating habits and is putting on weight there is a tendency to relax the observation levels a little, but good husbandry practices will always continue.

- Chicks must continue to be weighed daily until they are released to the wild from the brooder room or transferred to outside enclosures.
- Along with the weight gain, monitor chick condition (spine and hips), behaviour, sleeping patterns etc. and monitor yolk absorption by observing the size of the abdomen. Record all details in the chick notes.
- Check the amount and consistency of the faeces. As a chick gets older and starts ingesting more food, the faeces should continue to appear normal (white with

darker areas, mostly firm). It is useful to note the appearance of any unusual faeces and if any faecal matter has a strong odour. If this occurs, take a stool sample immediately for analysis. The incidence of coccidia within brooder rooms is very rare but it has occurred in some captive rearing facilities.

- Crop stones should be added to the brooder regularly. From around day seven to ten days as the chick is becoming established on the artificial diet. These are small river stones (of variable sizes, but usually around 2-3 millimetres) for the chick to ingest for use in the gizzard. These stones must be boiled for 10 minutes, drained immediately, stored in an airtight container in the brooder room before being sprinkled around the brooder. Only a small teaspoon is required per brooder. It is important not to add too many stones (to avoid the risk of impaction). More can be added later if necessary (day 14, day 21 etc).
- Check temporary leg bands regularly and re-band if necessary. Record all band change details in the bird records.
- Check for any activity in the large part of the brooder during the day and record. If any unusual behaviour is seen for a particular chick, investigate as necessary. This is especially important if chicks are being out and active during the day (in the large part of the brooder) or conversely have not been active overnight at all.
- The late afternoon is the best time to give each chick its evening food. Placed in dishes dotted about the large section of the brooder.
- Make sure the lights are turned off at night after the chicks have been fed for the evening.

12.3.8 Monitoring Yolk Absorption

- Chick abdomens should be monitored for the first two to three weeks of age, as this is a critical time to detect yolk sac infection, yolk retention problems or infections of the naval stalk (omphalitis).
- Careful attention should be paid to a chick that has hatched with an external yolk sac, large umbilical donuts, hernias, or slightly open navel.
- When a chick has ingested gizzard stones, they can sometimes be felt in the lower abdomen. But ingesting too many stones can lead to impaction of the gut. Refer to Kiwi First Aid and Veterinary Care, Morgan 2008 (p.57) for further information on diagnosis and treatment.
- On very rare occasions chicks may ingest soil. If this is occurring, the faeces will be black in colour, pebbly in appearance and when pressed between the fingers (wearing gloves of course) there will be a very high content if not all ingested peat moss material. If a chick is eating a lot of soil, they will not be gaining weight and food consumption will be poor. The peat moss (or leaf litter) should be removed from the brooder, and a layer of newspaper and then nonslip matting placed over the whole brooder floor. The chick can be given fluids to reduce rick of constipation and impaction and as a nutritional support. The chick will then remain on this matting until it is properly established on the artificial diet, then return the soil to the brooder usually using a smaller dish of soil first, as an introduction, before filling the brooder.

12.4 Care of Assisted Hatch and Malpositioned Chicks

Malpositioned chicks that have had any form of hatching assistance require a higher level of care and monitoring post hatch than chicks that hatch unassisted. Depending on chick position in the shell, leg and yolk problems are of the greatest concern.

- Pay careful attention to the position and relative angles of both legs when the chick is resting and being handled, as intervention is required at an early stage (especially for splayed legs). In general, if the leg position is incorrect as a result of malposition while in the shell, the legs will need to be taped with a spacer in the hatch room (refer to Appendix 2).
- Occasionally malpositioned chicks will need to be placed in a donut for a few days in order for them to remain in the correct crouch position, with an even distribution of weight on both tarsometatarsus (refer to Figures 17 and 18). After the donut, they can progress, if necessary, to a concave hollow made in the peatmoss (or cover a towel with matting and make a hollow) in the sleeping area of the brooder, with a mat pressed into it. This prevents the chick becoming cast on its side, especially if one leg is slightly weaker than the other. In this situation, position a small shallow water dish near the sleeping area.
- It is vital that leg position is closely monitored in the brooder when the chick is crouching more and becoming far more mobile. If the legs have been taped, they will need to be carefully checked for an improvement in the correct tarsometatarsus angle, to make sure that the spacer isn't too tight and that the tape is not rubbing on the leg.
- Once the chick appears to be holding the legs in the correct position, the tape and/or spacer can be removed (usually after a couple of days) but the chick will require continued monitoring of the leg position for the next week. This often coincides with the full health check at day five.
- Full assisted hatch chicks in a normal position require the same level of monitoring but may not have the same degree of leg problems.

12.5 Detecting Retained Yolk Sacs

A retained yolk is not just specific to problem hatch chicks (as it can occur in any chick) but the occurrence is very low (< 5 % of all hatched ONE chicks).

It is critical that chicks with retained yolk sacs are detected accurately and as early as possible. Any chick which has had either an assisted hatch, a prolonged or difficult hatch or has hatched with external yolk or an external umbilicus has the potential to have a retained yolk sac at a later stage. Similarly, a chick which shows no interest in feeding may also be a sign of a retained yolk sac.

All suspected yolk sac problems should be carefully assessed so that a chick does not undergo an unnecessary course of antibiotics or worse, surgery. It is also important to note that an infected umbilicus does not always lead to a retained yolk sac.

12.5.1 Symptoms of a Retained Yolk Sac

Chicks that had difficulties hatching or hatched with an external yolk sac or umbilicus have a greater risk of yolk sac retention or infection and should be monitored closely.

Symptoms of a retained yolk sac include:

- A distended swollen abdomen which will feel tight or doughy (this is not to be confused with a flatter firm abdomen).
- A normal post hatch weight gain which suddenly stops or even dips, especially if the chick has been eating unassisted. Any drop in weight of 15 grams or more (over one night) requires immediate assessment.
- Any sudden inactivity in the brooder. This may be difficult to detect with two chicks in a brooder. It is then important to observe both chicks' behaviour during the day (i.e., is one chick lethargic or depressed, coming out during the day?).
- Coming out during the day and spending time in the water dish, blowing bubbles, splashing in and out of the dish.
- A change in chick character (reduction in activity, alertness) and a depressed, hunched appearance, often with frantic running or probing behaviour.
- 'Daggy' wet faeces stuck to the feathers around the cloaca.
- Change in form and colour of the faeces, from a formed black and white scat to a greasy, brown often foul-smelling scat.

It is essential that the chick has at least two or more of the above clinical symptoms, to ensure that surgery is the most necessary course of treatment.

12.5.2 Retained or Infected Yolk Sac Treatment

Generally, yolk infections are rare, and the first approach should be a discussion with the vet as to if a course of antibiotics would be appropriate treatment initially before turning to the more invasive surgery to remove a retained yolk sac. Refer to Kiwi First Aid and Veterinary Care, Morgan 2008 (Pg 70-72).

The most 'at risk' age for retained or infected yolk is 12 to 16 days (but can be 10 to 25 days). It is extremely important to be alert and to assess all combined symptoms as a chick can die within 48 hours if it goes untreated. If you suspect a chick has an infected or a retained yolk sac notify the veterinarian immediately. It is important to place the chick on a course of antibiotics (as prescribed by the vet) as quickly as possible so that the infection can be checked prior to it becoming so serious that surgery is inevitable.

If antibiotics are prescribed, administer without delay, and monitor the chick carefully for the next few days. Usually, the antibiotics are very effective in stopping the infection, and the chick will respond by eating normally and putting on weight again within 24 to 36 hours. The rapid use of antibiotics has dramatically reduced the need for surgery for yolk issues at the National Kiwi Hatchery. The length of the course of antibiotics can vary a case-by-case basis but is usually prescribed for 5 days.

Below is the system used by the National Kiwi Hatchery if surgery is deemed necessary and the antibiotics have not worked. If you have any doubts please contact the team at the Hatchery, your local vet and/or the veterinarians at the Wildbase Hospital at Massey University Veterinary Hospital, to discuss the case in detail prior to surgery (especially if your vet has not carried out this type of surgery on a kiwi chick before).

- If a small (2 to 5 grams) weight loss, within a normal growth rate pattern, has occurred monitor the situation carefully for 24 hours. Not all chicks have a sudden rapid weight loss. Sometimes the first indication of a problem is a small change in a very stable increasing rate of growth. Observe the chick more frequently during the day, and clearly record on the chick notes that there may be a potential yolk sac problem. If there is uncertainty surrounding a possible yolk problem, seek veterinary advice immediately.
- The chick can be closely monitored for two to three days before a final decision on surgery is made.
- Once there is strong evidence that the chick may have a retained yolk sac and the antibiotics are not having the desired effect then contact your facility veterinarian to arrange a suitable time for consultation and possible surgery. Some captive rearing centres can send their chicks to Wildbase, for surgery but it is useful if a local veterinarian can carry out the surgery.
- If the chick has usually been assist fed in the mornings, do not feed it in case it will need to have emergency surgery that day. Weigh the chick prior to surgery.
- Place the chick in a small carry box with towels or padding to keep it comfortable and confined. Transport the chick to the vet clinic. In addition, have a heat pad for post-surgery transportation, and the individual chick rearing notes for the veterinarian to consider.
- Make sure the brooder is prepared for the chicks' post-surgery recovery before the chick returns from surgery. If the chick is housed on soil, remove all the soil from the brooder, placing newspaper and clean non-slip matting down over the entire brooder. Place a clean folded towel in the small sleeping section and cover this with matting. Turn a heat lamp on and check the temperature reaches 25°C at the height of the bird (the temperature should not exceed 28°C) and make sure the lamp is not too close to bird, especially if the chick is unable to move readily away from the heat source. The external heat source should be incrementally turned down over the next 24 hours, (dependant on chick behaviour). Chicks should be fully active 24 hours post-surgery, but if the yolk sac removed has been large, or the surgery long, the heat lamp may remain on for a further 24 hours.
- When the chick arrives back at the captive rearing facility after surgery it should be placed in the small 'sleeping' section of the brooder. The entrance to the large section should be blocked so the chick is contained in the small area for 12 to 24 hours, to minimise any vigorous activity. The chick should have access to the full brooder the following night post-surgery.
- The chick should be weighed post-surgery to get an accurate idea of the amount (of weight) the chick has lost.

- It is essential to continue to offer the chick food and water.
- Details of the surgery (such as time and duration of surgery, weight of yolk removed, complications, post-surgery recovery time, antibiotic regime, etc) should all be recorded in the chick notes.

12.5.3 Post Operation Support Care

- Hill's Prescription Diet a/d mix (artificial diet mix) should be given via a crop tube approximately 2 to 3 hours after surgery. This can be administered as a smooth slurry as described here, mix:
  - 1 tablespoon of Hill's artificial diet
  - 30 millilitres of warm/hot water to
  - 1 pea sized amount of NutriPet™
  - Mix thoroughly to a consistency that will easily flow through the crop tube. If the bird is dehydrated carry out rehydration therapy with electrolyte solution. Refer to Kiwi First Aid and Veterinary Care, Morgan 2008, (p 16).
- A second artificial diet mix feed can be administered early afternoon (depending on the time of surgery). A third dose may be necessary in the evening depending on the chicks' progressive recovery. If the chick is very young (~10 days), continue to administer the artificial diet the following day, especially if the chick has not yet established on an artificial diet. Most chicks will begin eating again within the next two days (some on the evening immediately after surgery).
- Weight may continue to decline on the day following surgery, but it should begin to increase again the following day. It is essential to provide the chick with enough fluid and food for recuperation.
- Normal food must be put out overnight.
- Check the sutures and spray the wound with 'Betadine' daily.
- Antibiotics must be given daily. The type and dosage of antibiotics should be discussed after surgery. Record the dose rate of all antibiotics given.
- Sutures should be removed ten days later, and then the soil can be returned to the brooder. Recovery is usually rapid and post-surgery survival is generally very high.

12.6 Operation Nest Egg Chicks Hatched in the Wild

Initially any wild hatched chicks are to be kept completely separate from those chicks which have hatched on-site at the captive rearing facility.

On arrival a wild chick is to be maintained under quarantine status until it has passed the initial quarantine, preferably in a separate brooder area or intensive care unit (ICU).

- A brooder should be prepared with soil, or non-slip matting, and water before the wild chick arrives.

- Protective clothing is to be worn when handling these wild chicks until the quarantine period is over.
- Hands should be thoroughly washed and sanitised between handling different chicks in quarantine or gloves worn.
- Young chicks (< 10 days) should be placed in a brooder with a heat lamp if they are cold on arrival. If heat lamps are unavailable, chicks are to be placed on a heat pad, and this is to be warmed regularly. This is especially important if a chick is cold on arrival.
- When handling wild chicks during quarantine, each chick requires a separate feeding towel, and a lab coat or gown is to be used for that chick only until the chick has cleared quarantine.

12.6.1 Wild Chick Arrival

- On arrival, it is important to obtain all necessary wild chick information and nest details from the kiwi field staff, especially the parentage of the chick and an approximate age of the chick if available.
- If the chick has hatched very recently (i.e., still wet from hatching), it will need to be placed in a warm brooder or TLC unit. Warm the chick gradually, monitor it carefully and when ready, move the chick into a brooder in an appropriate quarantine area.
- If the chick is over 48 hours old, place it directly into the quarantine area.
- Weigh the chick.
- Carry out a full physical examination:
    - Collect a stool sample as soon as possible to check for coccidia and nematodes etc, (hint: check the carry box the chick was transported in). This can be very difficult depending on the age of the chick as the very young or recently hatched chicks to not defecate a large enough sample to be collected. Check for a sample every time the chick is checked.
    - Take a cloacal sample and test for Salmonella and Yersina. If the chick appears unhealthy also take a blood smear.
    - Check the navel area carefully.
    - Check for ticks and mites and treat if necessary.
    - Check for any injuries, swellings, bite marks, eye infections, etc. If injuries are detected contact your veterinarian immediately for advice.
- Estimate chick age based on the presence of yolk in the abdomen, weight, body condition, feather condition, etc.
- Older chicks (5-6 days onwards) will require overnight food.
- Record all details on the individual chick notes and draw up a weight graph.
- It is preferable if wild chicks are placed in separate brooders on arrival, but this is not always possible. If more than one wild chick of the same species is brought in within 24 hours of one another, they can be housed in the same standard brooder

together (if of a similar age). The chicks must be identified with a temporary band, immediately. If wild chicks are put together it is important to watch out for early signs of dominance, especially if one chick is bigger.

12.6.2 Wild Chick Care while in Quarantine

- Brooder care is maintained as normal (refer to Section 12.2).
- Establish the chick onto the artificial diet.
- Once quarantine has been passed (i.e., clear stool and cloacal sample), the chick can be transferred into the main brooder room (approximately 7-10 days). If space is unavailable, treat the chick as if it were in the brooder room. If the samples are positive, treat the chick as appropriate or seek veterinary advice.
- If the chick is due for an early release, follow all release quarantine procedures (refer to section 15.3).

Minimum Standard 14.
Initial wild chick care and quarantine

a) All wild chicks arriving on site must be separated from all other chicks and undergo an initial quarantine period. Once all necessary stool, cloacal (and in some instances blood) samples are returned as clear the chick can be placed into a brooder room or outdoor enclosure.

b) Place the chick in a clean brooder containing a darkened sleeping area, an external heat source (if necessary), suitable damp substrate or non-slip matting and clean water. Fresh water is to be provided daily and food, once the chick is the appropriate age.

c) Clearly label the brooder with the chick's identification details and ensure the brooder number is recorded in the chicks' notes.

d) If two wild chicks are to be placed in the same brooder, apply a temporary leg tag to both of the chicks and clearly note this on the chick records.

12.7 Summary of Daily Brooder Care

Early morning duties

- Every chick should be weighed, and the weight plotted on the growth chart.
- Check the appearance of the faeces and remove all faeces from the brooder.
- Supply fresh bedding (fern fronds, leaf litter, clean towel, or non-slip matting) in the sleeping area.
- Scrub and refill the water dish with fresh water.
- Remove any old food, including food that has been flicked out of the food dish overnight. Weigh the leftover food and record the amount of food consumed.
- If using peat moss or leaf litter, dig over and water if necessary. Change the matting if soiled.
- When handling a chick during the daily weighing, check eyes, nostrils, general condition, and chick behaviour.
- Any chicks requiring feeding assistance should be fed as soon as possible in the morning.
- Weigh out and supply fresh food during the day (in the sleeping area) if the chick is not yet established on the artificial diet.

Late afternoon duties

- Supply fresh evening food.
- Quietly check on the chick and note if the chick has been active at all during the day.
- Make sure that all lighting is turned off at night, and the doors are securely locked.

13. Care of Chicks in Outdoor Enclosures

There are a number of different scenarios for Operation Nest Egg chicks to reach a safe release weight. A percentage of birds will stay on site at the captive rearing facility, being raised in outdoor individual pens built especially for this function. They stay there until they reach the weight of 1,000 grams. The actual release weight is determined by the aims of the individual kiwi recovery projects and can vary for different areas. The chicks will be fed the artificial diet while in these pens and their management is described within the next few pages.

The second most common outcome is that chicks are released at 3 to 4 weeks of age, (once they have surpassed their hatch weight), directly from the brooder room into a temporary crèche site. Such as predator free island or predator fenced area. At these sites, they roam and forage as they would in the wild, until they reach a safe weight to enable reintroduction back into the wild. Once released into a crèche environment then it is the Kiwi Best Practice manual that should be used for chick husbandry management, not this Operation Nest Egg best practice manual.

13.1 Transfer of Chicks to an Outside Enclosure

It is important to assess each chick individually before deciding when they will move into an outside run. Important considerations are total weight and overall weight gains, how long the chick has been eating independently, the age of the chick, hatch, and health history, who the chick is to be paired with in a run (if applicable), the final destination of the chick, (crèche site, island sanctuary, outdoor enclosures etc), and the availability of outside enclosure space.

For all ONE kiwi recovery projects the release weight, and location chicks are to be released into, should be determined at the start of the breeding season, (although the exact details may change over the season), so that appropriate management plans are in place before the chicks start hatching.

In general, a chick should go into an outside enclosure when it:

- has surpassed hatch weight,
- has a consistent regular weight gain, and
- is eating the artificial kiwi diet independently.

It is important to move a chick to an outside enclosure as soon as practical to ensure that chicks are not held in the brooder for unnecessary extended periods of time.

It is recommended, for identification purposes, that all chicks are microchipped before leaving the brooder room and transferred to an outdoor enclosure to ensure there are no identification mix ups when large numbers of kiwi are held on site at a captive rearing facility.

13.2 Release of Chicks from the Brooder Room to a Crèche Site

Before a chick is released into a crèche site, it must have regained its hatch weight, which takes on average three weeks. This will ensure that the yolk is fully absorbed, the chick is eating unassisted and has regular weight gains enabling it to better cope with the stress of release and is deemed fit and healthy.

- Communication with the individual project is essential at this time so that release dates can be co-ordinated with quarantine times, to ensure chicks are released as soon as possible and practical.
- A microchip is to be implanted subcutaneously under the right wing four days prior to release. This allows the implant site to be re-checked on release day.
- If DNA sexing is required, it is important to make sure that feather samples are taken before they are released.
- It is important that any required disease screening has been successfully completed and each chick has been given a pre-transfer health check by a senior experienced staff member or veterinarian before release.

13.3 Transponders

A few days prior to being put into outside enclosures, (or release into a crèche site), Operation Nest Egg chicks should be microchipped. It is recommended that this carried out once the chick has regained its hatch weight.

Transponders (microchips) must be inserted by a suitably trained person. Refer to the Kiwi Best Practice Manual (Robertson and Colbourne, 2003 [updated 2024] section 6.3.3 page 32) for instructions on inserting a transponder, and to the Brown Kiwi Husbandry Manual (Fraser & Johnston 2009), for supplier details. There is also a training video to view on: https://www.youtube.com/playlist?list=PL-N-bRAzQiU7qJPQ3Nz9poYI9isIUJiNE

The transponders currently used for Operation Nest Egg kiwi in New Zealand, are from Sure Pet Care (a subsidiary of MSD Animal Health). They are called MiniChips or Thermochip Mini. Your vet will have access to them.

13.4 DNA Sexing Methods

Chicks that hatch in captivity as part of the ONE programme are not required to be DNA sexed. However, individual project partners may still request captive rearing facilities to carry out feather collection for DNA sexing as part of their programme objectives. Feather collection techniques are outlined in the Brown Kiwi (Apteryx mantelli) Husbandry Manual (Fraser and Johnson, 2009 [updated Barlow and Travers, 2015][Jenkinson and Bean, 2024])

13.5 Transferring Chicks to the Outside Enclosures

Chicks can be moved into outside enclosures at any time of the day, but it is not recommended if the weather forecast is for heavy rain or unsettled cold weather. Chick enclosures should have a minimum useable area of at least 15 m2. Two chicks may be placed together in an enclosure of at least 30 m2, and if absolutely necessary three chicks may be placed into large enclosure (at least 50 m2) but this is not ideal.

To minimise disease transmission risks, it is important to only place chicks of the same kiwi species together, and not to place them in runs that have held other kiwi species. Try and pair chicks with similar release areas, similar weights when in the brooder room, or similar final release weights.

- The runs should be fully prepared before the chicks are transferred to the enclosure. This includes new burrows, (two good burrows per chick, either artificial or natural), dug over soil, clean food boxes/tunnels and water dishes. If present, any long grass should be trimmed and vegetation in the runs should be pruned periodically when the run is empty. It is essential to use a metal detector to check for metal objects in the soil (e.g., nails, fence staples, etc) that chicks may ingest.
- If the chick has been microchipped, scan and check the microchip number and check the microchip site before the chick leaves the brooder room. Remove any temporary tape leg bands.
- Record the chick weight, pen ID number and date the chick is transferred outside in the chick records. Make sure the outdoor enclosure is clearly labelled with the identity of the resident chick. The simplest way is to record it on a small whiteboard, or plastic weatherproof tag, which is attached to the gate of the outdoor enclosure. If there are two chicks in the pen, ensure both names and identity codes are recorded.
- In order to obtain accurate food consumption records chicks are required to be in fully enclosed outdoor enclosures. Most captive rearing facilities are unable to cover their outdoor pens, in which case they tend to use a system of ‘rubber flaps’ on the feeding boxes and tunnels to restrict access to the food from diurnal birds such as blackbirds. The kiwi chicks will need to be ‘trained’ to go through the flaps while still in the brooder room if possible (refer to Section 12.2).
- Chicks should be placed into separate burrows. Their evening food should be put in with them or in the food tunnel, (if used), with the tunnel being placed at the entrance of their burrow (be it natural or artificial), basically ensuring the chick must navigate past the food to get outside for the first few nights. If food is placed into the burrow with the chick, it is important to remove all uneaten food daily when cleaning.
- After two nights the food dish can be gradually shifted to the food tunnel/box system. If flaps are used on the box, keep one flap open. Within the first week the chick should be confidently going into the box to eat and gaining weight. If the chick is not settling into just the one burrow and is moving between burrows in the pen, it is important to move the food box system with the bird for the first few days until it is able to easily locate the food.

- Food, (for both adults and chicks), is best put out at the end of the day/early dusk to prevent the artificial diet from drying out, especially during the hot, dry summer months.
- Once the chick is confidently going in and out of the food box, start to move the food box away from the burrow entrance. It is important to closely monitor food consumption, especially when there is more than one chick in an enclosure. This is an important stage, as a chick can go downhill very quickly if it is not monitored adequately when it is initially placed outside.
- Pay attention to where a chick is roosting. Dominance behaviour is fairly rare, but in some cases, chicks will need to be separated. Signs to look for are if one chick is not gaining (or even losing) weight, fighting is evident, the less dominant chick looks scruffy, or if there is any other concern about the chick, separate the two birds.
- Once the chicks go outside, they need to be placed onto the regular weigh and faecal (stool) sampling schedule. They should be weighed on day two after transfer to the outside enclosure and undergo a quick health check. (Refer to Table 3 Disease Screening).
- Each chick must be sighted daily, (usually when the food dishes are collected each morning). If enclosures are large and chicks are using natural burrows, it is important to move carefully within the enclosure to prevent accidentally collapsing a burrow on top of a chick.
- Leftover food from the previous night should be weighed and food consumption recorded daily. If food is untouched, and a chick is losing weight, place food in with the chick during the day. Any dishes left out during the day must be removed from the food box before the night food is placed out. Make sure food consumption is carefully recorded the following day.
- When handling a chick to weigh it, always carry out a quick health check. This consists of checking from "tip to tail". Check the eyes, ears, nostrils, and gape (throat) and bill edge, plumage and general body condition, spine and hips, legs, feet, abdomen, and general chick behaviour (snappy, subdued). Also check around the wing base, in the featherless tract for mites.
- If DNA sexing is required, feather samples should be taken as soon as possible after the bird starts moulting the smaller chick feathers and the new feathers are coming through. This is roughly at 550/650 grams, (but can be earlier).
- All Operation Nest Egg chicks should be regularly weighed while they are held in outdoor enclosures until their release back into the wild.

13.5.1 Monitoring Chicks in Outdoor Enclosures

It is important that weight and stool schedules are followed to ensure the optimum health of all Operation Nest Egg kiwi chicks. If low food consumption is noted, (less than 100 grams overnight), this should be monitored closely for two to three nights. If there is no increase in the amount of food consumed overnight after two nights, the chick should be weighed and undergo a full health check. If there is little or no food consumed overnight, the chick should be checked immediately. All chicks should have fresh faecal samples collected for internal parasite screening (Refer to Section 14.2).

13.6 Maintenance of Outside Rearing Pens

- Footwear should be changed on entering the enclosure that contains the pens.
- Hands should be washed before handling kiwi or equipment.
- Conscientiously remove all faeces from the pens daily, using separate buckets, trowels for each pen.
- Kiwi food boxes, tunnels and artificial burrows should be cleaned regularly using disinfectant to minimise disease risks. It is imperative that these boxes are rinsed thoroughly and aired for as long as possible before being put back into the kiwi pens (to prevent respiratory tract irritation).
- The location of these boxes and burrows should be moved regularly to reduce the build-up of faeces in the feeding and sleeping areas. No boxes should be placed along the fence lines. Refer to Brown kiwi (Apteryx mantelli) husbandry manual (Fraser and Johnson, 2009).
- Use natural material on the floor of the artificial burrows and replace regularly (fern fronds are ideal but they must not have spores on them), do not use hay or straw.
- Resting the pens for at least 2 weeks between chicks going back into the pens. Allowing the pens to lie fallow for as long as possible between seasons (preferable several months)
- Food and water should be placed on an easy clean surface and any food waste or build-up of faeces should be removed on a daily basis.
- The outer perimeter of the pens should not be dug over, just a small, specific area within the pen, to allow them to dig and probe easily.
- All vegetation should be pruned back to allow the ground to get some sun exposure.
- All quarantine protocols should be obeyed for birds in quarantine prior to release back to the wild
- When entering a quarantine pen, only quarantine boots/footwear (with organic matter removed first and thoroughly scrubbed in Sterigene or another suitable disinfectant, on a regular basis) should be used in the specific individual ONE kiwi pen area. Once the bird has been released the boots must be sanitised using Sterigene before re-use.

Minimum Standard 15.
Care of ONE chicks in outdoor enclosures

a) Birds must be visually sighted each day.

b) Leftover food is to be collected daily and all remaining food is to be weighed and recorded to determine food consumption.

c) All faeces are to be removed from the pens daily

d) Fresh water is to be provided at all times.

e) Fresh food is to be provided as late as practical each afternoon or evening.

f) Food boxes and water dishes are to be cleaned regularly (at least weekly).

g) Faecal sampling and screening for internal parasites must be undertaken for all ONE kiwi chicks.

14. General Health Observations

As with any animal kept in captive environment, kiwi chicks will be exposed to a variety of pathogens (viruses, bacteria, and fungi), potentially at higher concentrations than they would find in the wild. High levels of hygiene on site, along with excellent husbandry practises, staff observations and immediate vet consultation and care, is vital, if health issues are to be managed well and to reduce the risk of infectious diseases effecting all the birds on site.

To help with health management, the following points should be considered for each chick every day.

- Food consumption. This is an important indicator of overall chick health. Has there been a decline in the food consumed?
- Where is the bird sleeping? Is it the usual burrow? or a different one, or not in a burrow at all? Does the bird regularly change burrows?
- Is the chick active during the day? This can be a strong indication that the bird may be unwell. Note: for a chick recently transferred to a new enclosure, activity during the day can be due to a period of adaptation to the enclosure and feed boxes.
- Are there any flies around the entrance to the burrow or sitting on the chick? Any flies' eggs on the chick?
- Sleeping position? Is the bird lying on its side? Curled up normally or crouching and alert?
- Attitude of chick if disturbed, (i.e., is it snappy, growly, alert, or subdued?)
- Observe the bird's faeces in the pen/sleeping box. Does it have a strong sour-smelling odour? Is it runny or unformed, or is it black and greasy indicating coccidia? Is it lacking the white uric acid component?
- Is the food being presented fresh and in good condition?
- Are there any potential disturbance factors, such as dominance behaviour from other chicks, or any foreign noises, such as construction or fireworks?

Any changes from normal behaviour should be noted in that chicks' file. These observations must also be verbally passed on to other members of staff and followed up to maintain continuity of the health and wellbeing of the bird.

14.1 Physical Check

Once a bird has been transferred outside, a comprehensive check should be done regularly when a bird is handled, usually when the chick is weighed. Ideally, two people are required to carry out a full health check, one to hold the bird and

the other to carry out a full visual health check. All relevant information should be noted. This check does not take a long, especially if you are familiar with the birds, and it is important to cover all the points mentioned below.

- **Eyes.** Are they clear and bright? If the eyes are "glued up" they can be bathed in saline solution. If the condition does not clear after a couple of days or there is an obvious mark on the eye, a veterinarian should be contacted (see section 14.3.2).
- **Ears.** Are they clean and clear with no scabs, mites, discharge, or discolouration?
- **Bill.** Is it closed, clean and a good ivory/soft pink colour? Any scratches, blisters or keratin peeling off?
- **Nostrils.** Are they clear, a pale ivory pink colour and free of any soil? Any stress bubbles?
- **Throat/Gape.** Is the tongue, glottis, and throat pink in colour? The mucous should be clear and not 'sticky-looking' or cloudy. White spots on the inside of the mouth are indicative of a possible yeast infection 'candidiasis' caused by Candida albicans.
- **Spine.** Start at the shoulders/base of the neck and quietly feel down the length of the spine and across the pelvis. A bird in poor condition will have a prominent bony spine and pelvis (often seen in young chicks from the wild) while an overweight bird has a spine that is difficult to feel and overall, the condition is usually quite rounded.
- **Feather condition.** Is there any indication of moulting with new feather pins coming through, obvious feather banding showing, indicating the chick had a fever or are there dirty feathers around the cloaca?
- **The presence of mites, particularly around the wing, ears, and eyes.**
- **Stomach.** The abdomen should feel firm, and gently rounded, (not too tight or bloated, not puffy or doughy or for that matter, hollow and empty).
- **Legs and feet.** Feel the joints down the leg to make sure they are not swollen or 'hot' to touch and that the scales (scutes) are not sloughing off. Check the feet and toes are not swollen or have any foreign objects puncturing the skin (e.g., thorns), also that there are no blisters/warts forming. Or that the skin on the leg is loose indicating dehydration.

14.2 Endoparasites and Routine Stool Testing

Routine stool sampling is the best, non-invasive way of determining if a chick has internal parasites such as coccidia, nematodes and cestodes.

The best method of collecting a sample is:

- On the morning the sample is taken, collect all faeces produced over night in that pen and pool that sample. This is because parasites shed their eggs intermittently, and taking only one sample is not a good representation of the presence of parasite eggs, as that one sample might have very few or no eggs within it.
- Make sure the faeces are not contaminated with soil or leaf litter.

- Ensure that you request that the sample is homogenised prior to analysis to reduce the risk of 'oocyst' hotspots that could affect the results and always confirm the laboratory uses the 'Faecal Float' Technique.
- It is best to use the same laboratory and the same team of technicians, if possible, for consistent results.
- Results should be back from the laboratory within 24 hours.

Coccidia are protozoal parasites which primarily infect the intestinal tract but can also infect the kidneys, liver, and blood of mainly juvenile kiwi. These are a natural parasite of kiwi, being found in both wild and captive birds. Coccidia are highly species specific, and it is likely that the coccidia species found in kiwi are not found in any other species. Consequences of infection with coccidia are related to the infective dose, with higher densities of birds resulting in higher levels of environmental contamination. This in turn will subsequently result in a higher exposure of birds to coccidia. Low burdens of coccidia in kiwi do not necessarily cause clinical disease, however, heavy burdens may cause morbidity, including weight loss, inappetence, diarrhoea and general lethargy, and untreated disease may result in mortality.

Coccidial oocysts are extremely resistant in the environment and are not destroyed by conventional disinfectants. Management revolves around reducing environmental contamination, regular stool sampling and recognition of infection in individuals, with treatment when necessary. It is important to recognise that young kiwi must be exposed to low levels of coccidia for them to acquire immunity to the parasites. It is not possible to completely eliminate coccidia from their environment. Rather the aim is to limit the dosage of coccidia that young birds are exposed to, while still allowing them to acquire a natural immunity.

Methods of reducing a build-up/ingestion of oocysts with in the pen environment:

- Pick up and remove all visible faeces daily from the enclosure. Using a separate scoop/trowel and bucket, for each pen you have.
- If possible, or the pen design allows it, replace the substrate in the pens annually.
- Minimise the stocking density of the pens.
- Rotate the pens used or rest them for as long as possible. A year or two is preferable.
- Ensure that food and water is provided on 'easy' clean surfaces (concrete paving stones).
- Provide food and water bowels that discourage kiwi from walking (and pooing) in them.
- Manage roost boxes so that they can be cleaned regularly to remove faeces while in use.
- Regularly change the position of the roost boxes, between pen usage, ensuring that the next chicks to use that pen are not sleeping in the same area that the previous chicks slept in.
- Use wood shavings or preferably, natural material, such as fern fronds, on the floor of the roost boxes. Replace the nesting material regularly or as soon as they are soiled.
- Between chicks ensure all roost boxes are disinfected well and allowed to dry fully.

It should also be noted that there is ongoing research into the treatment of coccidia, as there is concern that the over use of specific drugs, in particular the Coccidioides may result in an interruption in development of natural immunity to the parasite, as well as running the risk of development of resistance of the parasite to the limited number of drugs available to treat coccidia. Therefore, rotating the treatment drugs regularly i.e., annually is considered appropriate. Currently, Baycox (toltrazuril) and Coxiprol (amprolium) have been used in kiwi.

All facilities that raise kiwi chicks in outside pens will use their own health 'standard operating procedures' that they have written in consultation with their vets. It is very important to constantly review processes used and update any changes in dosing schedules. Including the type and concentration of drugs used. And while communicating with other facilities that have had experience with coccidia, is very important, it is your vet that you rely on, for the details needed for the treatment of the birds on site, under your care.

Table 3: On the following pages are the disease screening and treatment recommendations for ONE chicks.

	Diagnostic faecal for parasitology	Diagnostic faecal for parasitology	Husbandry Recommendations for coccidia:	Treatment for Helminths	Cloacal swab for microbiology (salmonella and Yersinia only)	Procedure if positive for Salmonella or Yersinia	Blood Smear for White blood cell count and haemoparasitology
Wild Chick Arriving to brooder	✓	+ and ++ Baycox, treat then retest 7 days. +++ to ++++ Baycox, treat and retest 7 days. Monitor carefully for - faecal consistency, hydration status, food intake and weight. May require supportive care.	Hygiene – remove faecal material at least daily, immediately remove food/ water bowls if contaminated with faeces.	Capillaria – if >200 epg. Stronglyids, Heterakis, Ascarids – if any +ve Tapeworms (cestodes) no treatment*	✓	Isolate individual. Observe strict quarantine principles. Seek experienced veterinary advice.	×
Management of Chick in Outside pen	✓- repeat weekly for duration in the pen. Diagnostic faecal for parasitology	+ no treatment if showing no clinical symptoms. retest 7 days. ++ Baycox, treat retest 7 days. +++ to ++++ Baycox, retest 7 days Monitor faecal consistency, hydration status, food intake and weight. May require supportive care	Daily faecal removal from pens and feeding areas to minimise infective dose of coccidia oocysts. Continue general pen hygiene processes.	Capillaria – if >200 epg Stronglyids, Heterakis, Ascarids – any +ve Tapeworms (cestodes) no treatment*	×	Do not move bird or birds in contact. Isolate individual. Observe strict quarantine principles. Seek experienced veterinary advice.	×
Brooder to Wild or Creche	✓	>++ or higher, Baycox, to avoid stress related disease issues upon release.	n/a	Tapeworms (cestodes) no treatment* Treat all other positives, recheck those with +++ and ++++ in 5 days before release	Optional – but considered best practice	Do not move bird or birds in contact. Isolate individual. Observe strict quarantine principles. Seek experienced veterinary advice.	Optional – but considered best practice.
Outside Pens to wild	✓ Follow recommended quarantine processes in the following chapter	>++ or higher, Baycox, to avoid stress related disease issues upon release.	n/a	Tapeworms (cestodes) no treatment* Treat all other positives, recheck those with +++ and ++++ in 5 days before release.	✓	Do not move bird or birds in contact. Isolate individual. Observe strict quarantine principles. Seek experienced veterinary advice.	✓

Coccidia treatment justification

- With low burdens (+) of coccidia, and only where there are no clinical symptoms along with accurate health records for the bird, would no treatment be considered.
- Low to Moderate burdens (++) should be treated to reduce environmental contamination.
- High burdens (+++ and ++++) should be treated to reduce morbidity/mortality of individual birds, as well as reducing environmental contamination.
- Faecal sampling – pool samples from individuals from overnight samples only (previous days faecals should have been removed the day prior). This is because the highest burdens of coccidia eggs are excreted between 3-7a.m., therefore the samples are most reliable.

NOTE: It is STRONGLY recommended that all measurements for coccidia management are employed (see section 14.2) because drugs are not an effective substitute for environmental management and overuse of drugs can result in drug resistance.

IDEXX scoring chart for coccidia (oocysts per gram):

+ = 0-2,000.
++ = 2,000-50,000.
+++ = 50,000-250,000.
++++ >250,000.

Therapeutics – check calculated dose rates with veterinarian if unsure. These are the recommended formulations for kiwi – there are others also which may be used (See Morgan 2008 p. 100).

*Cestodes may be treated if high numbers and birds are clinically ill, but infection with cestodes is not normally associated with clinical disease.

Kiwi stool samples should be tested for all the following internal parasites.

Ascarids, Strongyle, Heterakis, Capillaria (Nematodes), Coccidia (Protozoa) and Tapeworms (Cestodes).

Be aware that host specific endo and ectoparasites of rare fauna can be even more threatened than their host. You should leave the parasites alone unless they are causing health problems to the host.

Indicative treatments for different parasites and diseases are outlined in Table 4 below. Note that a veterinary surgeon should always be contacted if there are any concerns about the health or treatment of any chick.

Condition		Treat with	Dose rate – according to your vet directions.
Ascarids, Strongyle, Heterakis and Capillaria	Roundworms (Nematodes)	Ivermectin (or Moxidectin).	One treatment administered to the bird via a crop tube. Re-test after 14 days
Tapeworms	Cestodes	Droncit (Praziquantel)	One treatment administered to the bird via a crop tube. Re-test after 14 days
Coccidia	Protozoa	Baycox for piglets. (Toltrazuril)	One treatment administered to the bird via a crop tube. Repeat dose in 7 days' time.
Lice, mites, and ticks	Lice- insects Ticks & mites- arthropods	Frontline spray, (off label use), Avian Insect Liquidator	One treatment at 6 pumps/kg body weight sprayed onto the feathers
Bacterial infections - enteritis, pneumonia		Antibiotics	Consult veterinary surgeon
Candidiasis (Thrush)	Yeast infection	Nilstat (Nystatin)	Vet consultation required
Aspergillosis	Fungal infection	Nizoral (Ketoconazole)	Vet consultation required
Eye infections, scratches, or ulcers		Saline wash and Conoptal or Chlorsig	If saline wash does not show rapid improvement, vet consultation required.
Over-ingestion of crop stones		Metamucil	Half teaspoon per 150 g food
Campylobacter jejuni		Antibiotics	Consult veterinary surgeon before treatment commences

For a complete reference to treatment of parasites in kiwi refer to Kiwi First Aid and Veterinary Care, (Morgan 2008) and directions from your vet. Most dose rates are calculated on a weight basis.

14.3 Other Diseases to be aware of in Kiwi.

There are many variable diseases and disorders that you will come across while caring for kiwi and although this is not a document that will tell you how to treat these diseases (as discussed, that is a job for your veterinary surgeon). It does help to have some reference to refer to, especially if you have not seen this particular disease before.

14.3.1 Avian Pox (Avipoxvirus or AVP)

Avipoxvirus is a large, highly infectious virus able to survive well in the environment, particularly in debris from the host (like shed scabs) and in infected carrier birds, often in introduced species like Blackbirds and Starlings. The virus can withstand desiccation and many disinfectants. It is spread largely by biting vectors such as mosquitoes, but transmission can also occur by direct contact with an infected bird, or contact with infected debris on surfaces, equipment or in airborne particles. To infect a host the virus must be either injected into the blood stream, i.e., by the mosquito, enter through pre-existing skin abrasions or through contacting mucous membranes like inside the mouth or vent.

Lesions start off as a very small scratch or bump usually in areas of high wear, without feathers, in kiwi, commonly on the bill or less often, the lower legs and can be difficult to distinguish from any other scratch. The lesion them fails to heal and will show rapid growth and proliferation of tissue, that will distort the surrounding tissues and result in large areas of damaged tissue. The ulcerated surface of these lesions are very prone to secondary bacterial infection that can cause further injury, particularly in sensitive areas like the bill where there isn't much soft tissue between the outside and bone.

Confirmation of AVP is by PCR test or histopathology of biospy samples, but is rarely required with clinical signs being so suggestive.

The progression of the disease is usually "self-limiting" meaning it follows a course and resolves of its own accord. The main issues being if the lesion gets a secondary bacterial infection, is in a location that prevents the animal from moving or eating normally or the lesion is so large that when it heals there is a significant defect in the tissues at the site.

Treatment should be guided by your veterinarian, but the key features will involve supportive care to address these issues as the disease progresses and to isolate the infectious animal for the duration of disease to prevent contamination of the environment, equipment and exposure of other birds. To this end the isolation needs to be in a location that is easily cleaned and all debris produced by the bird can be contained and disposed of as infectious material. The animal is considered no longer infectious when the last lesion has exfoliated, although full remodelling of lesions that cause significant defects can take months. If lesions are not drying out and starting to exfoliate within a few weeks of diagnosis the case should be re-evaluated with your veterinary advisor as there may be secondary problems. Once recovered the bird will have good immunity to AVP.

Management in captive kiwi situations should include steps to reduce pen exposure to wild living, known host species and limit mosquito/biting insect numbers where ever practicable.

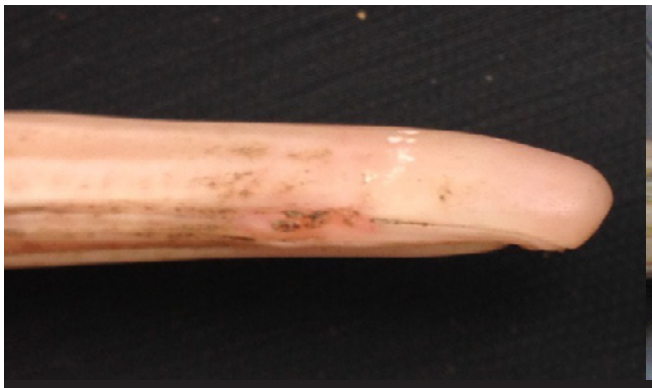


Figure 23. A bill showing slight changes along the median line of the mandible (Photo: National Kiwi Hatchery)

Figure 24. A pox lesion at an advanced stage, causing distortion of the bill tip. mandible (Photo: National Kiwi Hatchery)

14.3.2 Eye Ulcers

When handling a kiwi, both eyes should be checked as part of the routine health check. Often, there will be a small amount of dry soil that has accumulated in the front corner of the eyes (due to their probing activity) but they eyes themselves should be black, bright and clear. If the eye is closed with crusty discharge and/or soil this can be gently irrigated away using saline solution and a cotton bud. The bird needs to be monitored at least daily until there are no longer any concerns. Abnormalities you may notice with the eye include, the eye being held closed (indicating pain), an opaque colour to the cornea (clear curved front surface of the eye), the eye being sunken into the skull, any discharge other than a slight bit of clear fluid.. Any changes to the cornea should be investigated with your vet immediately. If the eye has any of the other signs and they continue over more than 48 hours seek advice from your

Investigation and treatment will be dependant on the intial veterinary examination inlcuding extra tests like fluorescein staining to highlight damage to the surface of the eye and evalutation for causes like foreign bodies under the third eyelid or abnormal feather growth. Treatment will usually involve application of antibiotic eye ointment multiple times a day. For deep or complicated lesions a hospital stay for intensive managment might be required and advice can be sort from Wildbase Hospital at Massey Uni.

Figure 25. An example of a healthy looking eye
(Photo: National Kiwi Hatchery)

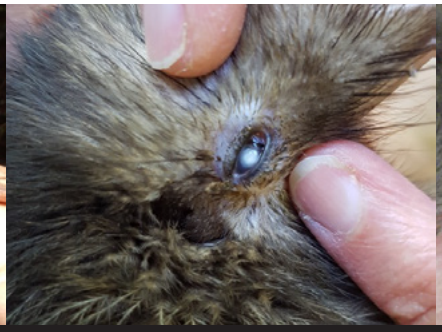


Figure 26. An example of a deep seated bilateral Ulcer
(Photo: National Kiwi Hatchery)

Figure 27. Fluorescein stain
(Photo National Kiwi Hatchery)

14.3.3 Folliculitis

Folliculitis occurs where the feather follicles have been infected, either by a bacteria, fungus or a viral infection causing the feathers to become misshapen towards the base as it emerges from the follicle.

It tends to appear in newly hatched chicks that have had a long or difficult hatch. It can be identified as excessive feather loss in the hatcher, often from the neck and thigh area and the feathers themselves have a bulbous end. (Figure 28. Example of feather that was shed due to folliculitis infection, Photo: National Kiwi Hatchery).

The chick may also have an unusual, fusty smell. And when you handle the chick, the affected areas can feel spikey as new feather pins emerge.

With a newly hatched chick, with a mild case, treatment may not be required initially but the chick will need to be monitored closely and kept isolated with a separate weigh box, gloves and separate scrub top used when handled, to reduce the risk of spreading any infectious agents to other chicks.

If the feather loss increases, the smell remains and/or the new feathers that grow are still mishappen the case should be evaluated by a veterinarian. Samples of feathers and the skin surface will be taken to look at under the microscope and potentially deeper samples like biopsies might be needed to determine the agent involved. Treatment may involve repeated cleaning with mild disinfectants or more likely oral microbials and anti—inflammatories. In severe cases treatment may be prolonged.

Figure 28. Feather showing signs of Folliculitis.

Figure 29. Evidence of folliculitis at the base of the feathers close to the skin. (Photo: National Kiwi Hatchery)

14.3.3 Mouth Plaques and Oral Candida

Kiwi in captivity can be prone to developing oral ulcers and secondary infections, usually with the yeast organism candida. Candida albicans is a yeast fungus that is widespread in the environment and at low numbers is likely normal gut flora in the kiwi. Candida can overgrow in the oral cavity when the kiwi is affected by a variety of factors and cause mouth ulcers that very in severity from very superficial, to extremely deep down to and affecting the underlying bone. Risk factors known or suspected to predispose to oral candidiasis include, prolonged antibacterial use, sticky batches of food, scratches to the oral mucosa and other conditions causing immunosuppression. In humans acute oral candidiasis has been linked to deficiencies in iron, folate, and vitamin B12, the role of these in kiwi with the condition is unclear.

When evaluating the oral cavity of kiwi any areas of redress, particularly with an overlying white to creamy yellow plaque are of concern. The most common locations for such lesions are immediately in front of the tongue on both the floor and roof of the oral cavity.

Advice should be sort from your veterinarian in all cases as the location and severity will determine treatment or management and very painful lesions can cause an otherwise healthy kiwi to go completely off its food. Treatment for mild lesions might be repeated topical cleaning with a mild disinfectant and addressing the risk factors, while more severe cases will likely need hospitalisation with systemic medication, topical treatment and possibly debridement of the lesion.

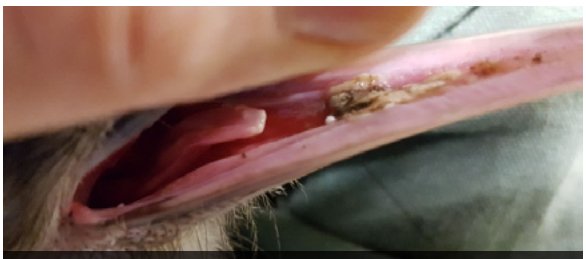


Figure 30 Mouth Plaques (Photo: National Kiwi Hatchery)

As always, when looking after the birds, on site in your facility there will be many more disease that you might come across. Having good hygiene systems, excellent communication within the husbandry team and with other facilities along with having a good relationship with your vet will pre-empt many health problems establishing into a disease outbreak.

14.3.4 Ventricular Worms

Ventricular worms are a species of nematode, that, unfortunately, very little is known about. It is thought to have an intermediate host species, for example beetles or cicadas, it is known that the juveniles are free floating and can be found in the birds ventriculus, proventriculus and the duodenum. Also that the adult females will embed deep into the ventricular wall.

Ventriculitis or ventricular nematodiasis occurs when the ventricular wall becomes ulcerated and inflamed due to the high burden of ventricular worms (esp. adult females), and this causes serious disease or death.

Symptoms can be difficult to determine as birds that have an infection of ventricular worms can be asymptomatic and will show no signs of being clinically unwell. But symptoms can present as fluctuations in weight initially followed by lowered consumption, inappetence and significant weight loss. Some birds will ingest a lot of stones, causing the abdomen to feel lumpy and/or graunchy. And faeces will be dark and tarry from excessive bleeding of the ventricular wall. If severe the mouth will be pale indicating signs of anaemia. Birds under stress such as moulting, any change in habitat, or other illnesses (endoparasite infection) are more susceptible to ventriculitis.

If ventriculitis is suspected, take a stool sample immediately and send away for a faecal flotation diagnosis for ventricular worms/eggs. Complete a health check, including palpating the abdomen, and checking the mouth for pale mucosa membranes. Discuss with your vet as they may prescribe a pre-emptive dose with Moxidectin immediately. In less severe cases, a treatment plan can be made in consultation with your vet and treatment takes place on site. But if severe the bird might need to be sent to Wildbase for further intensive treatment.

Prevention is always preferable and so outdoor pen maintenance is critical, see chapter 13.6, page 74 for maintenance of the runs.

15. Chick Quarantine

The release weight for kiwi chicks that stay on site, in predator free outdoor rearing pens is 1 kilogram. It is understood that at this weight they can usually defend themselves against stoats but are of course still vulnerable to ferrets, cats, and dogs.

Note that the quarantine procedures described below, are quite different from those applied to young chicks scheduled for release into a crèche area directly from the brooder room.

15.1 Chick Release from a Brooder to the Wild

Chicks that are to be directly released back to the wild from the brooder room still must undergo a short health check prior to release. The chick must have reached, or exceeded, its hatch weight and be in good general health and condition. Three days prior to the intended release date it must have a full health assessment done by a senior experienced staff member and a stool sample taken. A transponder should either have been inserted prior to this or be inserted at this time. If the stool sample returns a positive coccidia result the bird must be treated accordingly with Baycox. The stool result should be clear before the chick is released. On the day of release several factors should be considered prior to being given the okay to be released:

- Good food consumption overnight.
- It is preferable to have a weight increase but on occasion when a chick is ready for going outside the weight increases overnight can even out.
- The brooder should be well used, the water dish used and there should be plenty of well-formed faeces deposited throughout the brooder.
- The chick should be bright, alert, and responsive with no sign of any eye infections etc.
- Clean and dry entry wound where the transponder was inserted, no sign of infection.

15.2 Quarantine in an Outside Enclosure

Prior to placing a chick in quarantine, it must be in good general condition, have a healthy appetite, and corresponding good weight gain rate.

- Once a chick is placed into an outside enclosure it should remain in this enclosure until quarantine is completed and it is released. Sometimes chicks lose condition if moved unnecessarily.
- It is recommended that the quarantine duration for birds in outside enclosures is 21 days, and during that time the chick should continue to gain weight and maintain good health. In most cases the chick can be put in to quarantine between 930 grams to 950 grams, (if the desired release weight is 1,000 grams), but this

is dependent on the time of the year and the individual growth rate of the bird. It is important that the daily live weight gain (DLWG) is calculated for the previous month to determine if a chick will reach release weight within the quarantine period. Note, there are usually seasonal differences in rates of weight gain for chicks placed in quarantine.

- Also, the DLWG can drop, due to the extra handling for the quarantine testing.
- The proposed release dates should be closely coordinated with the relevant kiwi project personnel so that birds can be released as soon as the quarantine period is successfully completed.
- During quarantine the chick will undergo various health checks. These all must be clear before commencing the next stage of quarantine. Quarantine intervals should only be extended if a bird fails the quarantine test procedures and requires additional testing. It is important to inform the relevant kiwi project staff or conservancy that the quarantine period has been extended. This should be done promptly as the delay will immediately affect the proposed release date and plans, especially if it is to be a public release.
- If there are multiple birds in an enclosure, it is less disruptive to place these birds in quarantine together, if possible. The quarantine status applies to the enclosure and all bird procedures are carried out under quarantine conditions.

15.3 Quarantine procedures for Operation Nest Egg chicks in outdoor enclosures

Chicks should complete the following quarantine tests within a defined quarantine period.

Weight and estimated condition score × 2

Stool Samples x 3

Blood Smear x 1

Cloacal swab x 1

Transponder implanted (if not already done when the bird was transferred outside)

Feathers for DNA (if not already done)

- Once a chick has been put into quarantine, individual overalls or lab coat must be used when handling that bird. Overalls must be washed in Sterigene and dried between quarantine events.
- Separate footwear should always be used in the quarantine enclosure. These are not to be used in the rest of the enclosures and must be washed in disinfectant prior to use in the quarantine enclosure.
- Separate carry box used for weighing the chick/s in quarantine. This should be disinfected after use.

- A quarantine sheet is to be filled out for each individual bird when the bird goes into quarantine to ensure the quarantine process is correctly adhered to.
- It is important that a Q is written on the board on the door to the chick enclosure, and any kiwi enclosure location map, so all captive rearing staff are fully aware of which birds are in quarantine.

15.3.1 Cloacal Culture Sampling Method

Cloacal cultures are used to screen for Salmonella and Yersinia (Campylobacter is no longer tested for in the screening programme).

The following is suggested as a quarantine procedure (you can also refer to Kiwi Best Practice Manual, Robertson, and Colbourne, 2017 page 45, How to take cloacal swabs)

- Taking a cloacal swab should only be undertaken by staff that have been trained and accredited for these skills.
- Two people are required when taking a cloacal swab from a kiwi chick. One to restrain the bird and the other to take the sample.
- The person holding the bird should be seated and the bird held on its back, in the dip of the lap close to the knees, with hands firmly around the bird's thighs. It is useful to lightly cover the birds head to keep it calm.
- The person taking the swab should wear latex gloves. The plastic packet is opened, and the swab placed into the gel medium to moisten the end to prevent damage to the cloacal tissues.
- The cloaca should be located, and all feathers held out of the way with the left hand (refer to Figure 31 for a normal cloaca). Gently press down on the tail bump to slightly open the cloacal, (refer to Figure 32).
- Remove the swab from the gel and carefully insert it into the cloaca. Try not to touch anything with the swab except the cloaca itself.
- For simple insertion, gently twist the swab until the head of the swab is out of sight within the cloaca. If the bird struggles while the swab is inserted, release the tension on the swab without actually letting it go.
- Gently turn the swab inside the cloaca and carefully remove it, (refer to Figure 32).
- Place the swab into the medium tube as soon as it been removed from the cloaca and clearly label the tube with the bird's name and ID, date, and location.
- It is preferable to post the sample away to the laboratory as soon as possible. If there is a delay in posting, (i.e., if the sample was collected on a Sunday), then place the swab in the fridge until it can be posted the following day. Do not freeze the sample.

Figure 31. Normal cloaca of a young GSK chick. (Photo: Melanie Nelson)

Figure 32. Opening the cloaca (left) and taking a swab (right). (Photo: National Kiwi Hatchery)

15.3.2 Blood Smear Sampling Method

Blood sampling should only be undertaken by an experienced operator, (refer to Kiwi Best Practice Manual, Robertson, Colbourne, 2017. How to take blood samples). The method used to hold the chick in order to obtain blood for a blood smear is very similar to that used when taking a cloacal swab sample, and both tests are generally done together.

- The sample is taken from medial metatarsal vein running along the inside of the lower half of the right leg (tarsometatarsus bone) (refer to Kiwi First Aid and Veterinary Care, Morgan 2008, page19, for location of vein).
- The person restraining the bird must clamp the leg firmly around the hock joint (at the tibiotarsus and tarsometatarsus joint) which inhibits blood flow from the lower leg, thereby making the vein more turgid.
- The person taking the blood sample should gently twist the foot outwards. This helps to make the vein more visible, running slightly diagonally up from the dew claw.
- The vein area is then wiped well with methylated spirits and a very small (no more than to the first increment of a 1 ml syringe) sample of blood is taken using a 25-gauge needle.

- Once the sample has been collected and the needle withdrawn, apply a gentle pressure to the venipuncture site using a prepared tissue.
- If blood is not obtained from the right leg, repeat the procedure on the left leg. If still unsuccessful re-schedule the blood smear for another day.

Refer to Kiwi First Aid and Veterinary Care, (Morgan 2008) for instructions of how to prepare a blood smear.

For general quarantine standards for captive kiwi, refer to the Brown Kiwi Husbandry Manual, (Fraser & Johnston 2009).

Minimum Standard 16.
Quarantine of ONE chicks prior to release into the wild

a) All birds must be isolated in quarantine for a minimum of 21 days.

b) All birds must be weighed at the start and end of the quarantine period.

c) A faecal sample must be collected at the start of quarantine for chicks held outside and analysed for eggs of endoparasites, (Ascarid, Heterakis, Capillaria, Strongyle and Coccidia).

d) A cloacal sample must be taken at the start of quarantine for chicks held outside and analysed for Salmonella and Yersinia.

e) A blood smear must be collected at the start of quarantine for chicks held outside for a white blood cell count (WBC) and analysed for haemoparasites.

f) Before release all birds have a physical examination by a senior experienced staff member or veterinarian and are deemed healthy.

g) Only healthy birds can be released into the wild kiwi population. If medical checks or samples reveal health problems these should be resolved or adequately controlled before the birds are released from quarantine.

16. Record Keeping

There is key information that should be collected as part of any ONE procedure. These relate to all parts of artificial incubation and rearing, from the time the egg arrives on site at the captive rearing centre, until the chick is released back to the wild. Even if the egg is deemed dead on arrival, accurate date needs to be recorded about that egg.

Note that a lot of facilities are now recording all data on their computer systems on site, using record keeping systems such as ZIMS Species 360 (Zoological Information Management Software). This means less paper folders but relies heavily on records being kept within each room accurately, as you would with paper records and of course ample internet access to all rooms and an ample server to handle the data.

16.1 Egg Arrival and History

Information that should be recorded includes:

- Kiwi species
- Area of origin
- Bird's individual ID (or ZIMS number, if used)
- Sire and dam, (if known)
- Time and date removed from burrow.
- Time of arrival, (at captive rearing facility)
- Mode of transport
- Name of person who retrieved the egg from the nest.
- Egg timer transmitter attached and incubation details.
- First or second clutch
- First or second egg
- Brief nest history and any other field details
- Diagrams of stage of egg development

It is also useful to use a checklist to ensure the correct egg processing and preparation procedures are carried out before the egg is incubated. For an example refer to Table 5. Once the process is completed it should be initialled by the staff member responsible to ensure correct procedures have been followed.

Table 5: Example of an egg preparation checklist

Egg preparation room	Confirm	Incubation room	Confirm
Weight		Weight	
Candled		Candled	
Cracks identified		Initial estimation of age	
Small/Moderate/Severe?		Air cell drawn in.	
Position of cracks (Draw over pg.)		ID mark, mark top of egg	
Disinfectant & Concentration		Draw development of egg/cracks	
Water temperature		Length of egg	
Submerged/Splashed		Width of egg	
Time in water		Incubator type & number	
Master Conservancy sheet filled in.		Time into incubator	
Master Full Summary sheet filled in.		Incubator temperature & RH%	

16.2 Data Log for Artificial Incubation

An individual data log for each egg that is incubated should be maintained. Information recorded for every egg includes:

- Species
- Egg ID
- Estimated age of egg on arrival
- Incubator type (still air or forced draft) and incubator number.
- Start of artificial incubation (date into incubator)
- Egg weight when set.

A data table should be used to record incubation parameters, some information is required to be recorded up to four times a day, other data is taken as and when the egg is candled (two times a week).

For still air incubators, these include:

- Date
- Time
- Incubator temperature (at top of egg)
- Incubator % relative humidity
- Egg orientation

- Staff member ID
- Egg weight
- Actual % weight loss
- Egg age (and days incubated)
- Number of eggs in incubator
- Humidity tray levels and numbers
- General comments (egg development and candling notes)
- Movement detected.

For forced draft incubators, the parameters to record include:

- Date
- Time
- Egg weight
- Actual % weight loss
- Egg age (and days incubated)
- Incubator temperature
- Incubator % relative humidity
- Staff member ID
- Egg orientation
- Number of eggs in incubator
- General comments (egg development and candling notes)
- Movement detected.
- Egg cooling time (if used)

An incubation summary for each egg is useful for assessing incubation and hatching parameters. This is particularly important for South Island species, where less is known about incubation and hatching.

16.3 Hatching Notes

Detailed notes of each chicks hatch should be recorded. For each observation, note the date, time, hatcher temperature and candling details. Records can include notes and diagrams. ZIMS ID may be allocated to a chick at hatch (if used).

16.4 Chick Rearing Notes for the Brooder and Outside Enclosures

An individual data sheet for each chick that is reared should be maintained. Information recorded for each chick should include:

- Species
- Egg ID and chick name
- Bird's individual ID (or ZIMS number, if used)
- Hatch date
- Brooder/enclosure number
- ID of other chick in brooder or enclosure (if applicable)
- Temporary band colour
- Transponder number (if applicable)

A data table should be used to record daily chick rearing details. Information to record in the table includes:

- Date
- Age of chick (in days)
- Chick weight (including if the chick is gaining or losing weight)
- Amount of overnight food provided.
- Amount of overnight food eaten
- Details of any food provided during the day.
- General comments and notes of the brooder conditions.

16.5 Wild/Injured Chick Arrival Data Sheet

An individual data sheet for each chick that is treated in quarantine (wild chick arrivals, injured or sick birds) should be maintained. Chick information recorded includes:

- Species
- Egg or chick ID
- Estimated age of chick
- Admission date
- Brooder number
- ID of other chicks in brooder (if applicable)
- Temporary band colour
- Transponder number
- Discharge date
- Reasons for treatment in quarantine

A data table should be used to record chick treatment and health details. Information to record in the table includes:

- Date
- Daily Chick weight – including if the chick is gaining or losing weight.
- Treatment (medication, physiotherapy)
- Time of treatment
- Amount of overnight food provided.
- Amount of overnight food eaten
- Details of any food provided during the day.
- General comments and notes

16.6 Stool Sample and Quarantine Records

All stool samples taken must be recorded with the individual bird's ID and the test results. All quarantine tests, dates and results must be recorded. Sample categories include:

- Stool
- Cloacal
- Blood
- Vet reference ID
- Laboratory testing case number

Quarantine records must include:

- Individual chick ID (code and transponder number)
- Date quarantine started.
- Enclosure number
- Identity of other birds in the same enclosure
- Day one samples: Stool, cloacal and blood test (and test results); weight, condition, and full health assessment.
- Second stool sample (and result)
- Any required treatment (i.e., Baycox to treat coccidia, etc)
- Release date and weight

Minimum Standard 17.
Record keeping

a) Accurate records and individual identification are required for each ONE egg and chick, including detail on origin, dam and sire, species, incubation methods and daily parameters, hatch date, daily chick weights and rearing methods, medical treatments, and transponder implant number.

16.7 End of Breeding Season Reports

A summary of all ONE information collected by each captive rearing facility during the season is to be submitted to the head of the Kiwi Recovery Group in the form of an end of breeding season report. The kiwi captive co-ordinator will request a data table from each facility to provide to the Kiwi Recovery Group at the end of each breeding season. This will be collated for all facilities participating in ONE.

Minimum Standard 18.
End of breeding season report

a) An end of breeding season report must be submitted by 14 July for the year 1 July to 30 June. b) A template will be supplied, and information required includes:

- Numbers of all ONE eggs received on site, both alive and dead.
- Numbers of all viable ONE eggs incubated.
- Numbers of all ONE chicks hatched.
- Numbers of all ONE chicks released back to the wild.
- List of all egg and chick ID's including transponder number for the season
- A summary of all egg and chick post-mortem results

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18. References

Barlow, S. 2018. **Zoo and Aquarium Association Captive Management Plan for Kiwi Final 2018-2023.**

Bassett, S. 2009. **STK Operation Nest Egg Kiwi Egg Candling Workshop Study Guide.** STK, Save the Kiwi Trust, New Zealand.

Colbourne, R.M.; Bassett, S.; Billing, T.; McCormick, H.; McLennan, J.A.; Nelson, A.; Robertson, H.A. 2005: **The development of Operation Nest Egg as a tool in the conservation management of kiwi. Science for Conservation 259.** Department of Conservation, Wellington.

Department of Conservation (2010). **Blood and Feather Sampling Standard Operating Procedure.** Department of Conservation, Wellington.

Fraser, I & Johnson, T. 2015: **Brown Kiwi (Apteryx mantelli) husbandry manual. Version 3.** Kiwi Captive Management Advisory Committee and Department of Conservation, Wellington, New Zealand.

Holzapfel, S., Robertson, H., McLennan, J., Sporle, W., Hackwell, K., Impey, M. 2008. **Kiwi (Apteryx spp) Recovery Plan: 2008 – 2018. Threatened Species Recovery Plan No. 60.** Department of Conservation, Wellington, New Zealand.

Morgan, K. 2008. **Kiwi First Aid and Veterinary Care.** Department of Conservation, Wellington, New Zealand.

Robertson, H.A. & Colbourne, R.M. 2003 (revised 2017). **Kiwi Best Practise Manual. Internal report (QD code 1428).** Department of Conservation, Wellington, New Zealand.

Appendix

1. Assessing and assisting problem hatches.

To be able to assess the progress of a hatch accurately you will need to be familiar with the physiological procedures of a 'normal' hatch. This will enable you to recognise the various stages of that hatch process i.e., chick rotation, draw down, internal pip, external pip and then the actual hatch. Only by understanding what is considered normal will it become easier to identify what is "not normal" hatch behaviour.

Compounding this fact is understanding that each egg is unique and while there are general rules of thumb for a hatch timing (2 to 3 days at IP, 2 days XP), each egg will complete each stage in its own time.

This information will help to give you the skills to identify a situation where an egg is not progressing through the hatch process as expected and accurately assess whether you need to intervene or not. A small number of hatches will have problems, including malpositions and external yolk or external umbilici. These eggs will require assistance if they are to hatch successfully.

Procedures that may be required include artificial external and internal pip and x-rays, to physically remove the shell and hatching a chick. Details of these procedures are given below. Veterinary assistance may be required.

It is imperative not to assist a hatch unnecessarily or prematurely as the chick needs to be ready, physiologically, for pulmonary respiration and have sufficient time to internalise all yolk before hatching, but it is important to assist if the chick becomes weak or stressed.

1.1 Creating a view hole in to the air cell at point of hatch.

Creating a view hole is highly interventional and can dramatically change the environment within the air cell, this in turn can impact the remainder of the hatching process.

Before considering opening a view hole in to the air cell of an egg, re-assess all egg notes and egg characteristics, including your aging of the egg. Also note that with normal hatch processes, an egg will have 'rest' periods where it won't move, and the veining will change as part of the natural progression of hatch. An embryo must experience a degree of hypoxia prior to internally pipping (IP) through the membranes. The skill is in determining between an egg that is advancing normally through the hatch process and one that is struggling to achieve the hatch milestones.

See below for a check list of discussion points that need to be evaluated before the decision is made to put in a view hole:

1.1.1. Critical drop in movement:

- Consider the embryo's 'usual' level of movement for that egg. Some eggs will move a lot in late incubation, but others will have regular steady movement throughout incubation.
- Is there a critical drop in level and frequency of movement? i.e., is it small or very small?
- Is the egg in a 'rest' period? (If no movement seen but the veins are ok, put the egg back in the incubator for 20 mins and try again for movement)

1.1.2. Deterioration of blood vessels in the light band:

- Are they less crisp/vibrant?
- Have they thinned excessively, look less turgid or reduced in size and number?
- Have they changed colour?

1.1.3. Membranes and bill position:

- As you candle, do the membranes look 'tight', folded, or have a lot of movement in them still?
- Can you detect a bill shadow?
- Is the bill 'tenting' under the membrane, or lying much lower on the air cell edge?
- Is there a total absence of a bill shadow?

1.1.4. Embryo position and Pre-IP glow:

- Has the embryo slumped well into the air cell?
- Is there a strong pre-IP glow? Is it progressing?
- Can you define the hocks?

1.1.5. Suspected malposition of Embryo, minor and major:

- Chick body shadow appears correct but no bill shadow.
- Slumping is happening opposite side of air cell.
- Absence of any glow at the NACE, it is black instead.
- Waste deposits visible at the air cell end of the egg

Note:

Points 1.1.1 and 1.1.2 are the most important deciding factors when deciding to put in a view hole.

Remember: veins and movement will reduce at point of IP in a normal hatch. It is only when they reduce below the normal level or to a critical level that action would be required.

Points 1.1.3 and 1.1.4 help the decision-making process, where point 1.1.5 will help decide if an x-ray is required.

1.1.6 Method Used to put in a view hole.

- Wash the bench and ensure all equipment to be used has been properly sterilised. Equipment needed will be the candler, small Phillips screw driver – dedicated to view holes only – two sets of tweezers, small clamps, cotton buds, gauze pads and small phials of saline solution. These should all be sterilised. Then masking tape and clean matting.
- Re-sanitise hands before commencing any work on the view hole.
- Place the egg on a clean mat, candle the egg and identify any shadows or tenting that could possibly be the bill. If a bill shadow cannot be identified, estimate where the bill should be in a 'normal' hatch position.
- Draw a small (.5 cm) pencil circle on the shell, slightly to the left of where the tip of the bill should be. This hole can always be made larger if necessary.
- Place the egg sideways on the mat with the air cell towards the right, (if right-handed). Hold the egg firmly with the left hand and using the screwdriver gently tap the shell of the air cell right in the centre of the circle you have drawn, until you break through the shell and outer shell membrane. Using the tweezers, carefully remove small pieces of shell up to the pencil edges. Make sure that no shell fragments fall into the egg.
- You should then be able to investigate the air cell space. Immediately candle the air cell area looking for the bill or white bill tip, which may be seen tenting under the inner shell membrane. Check for bill movement too. Note the colour and form of the inner shell membrane, (i.e., crisp, white, damp, discoloured).
- If the bill is not immediately obvious, extend the view hole to 1cm diameter and use a cotton bud soaked in sterile saline to dampen down the areas of the inner shell membrane to locate the bill and determine vascular activity in the chorio-allantoic membrane.

1.1.7 Observation, Interpretations, Actions and Treatment

Normal membranes: If the membranes appear normal, that is they are crisp, clean and white looking, are not sucked down tightly over the bill or body of the chick (vacuum packed), the bill appears to be in the correct position (after it has been damped down with a cotton bud and saline solution) and the vascular system has been assessed as being 'active', an 'artificial internal pip' is not always necessary at this stage. Basically, if it all looks to be normal then tape up the hole and put the egg back in the incubator. It may be helpful to reassess the notes and this point and consider why it was thought necessary to put in a view hole.

Keep monitoring and reassess all the valid points again i.e., movement, veins etc. If the chick has subsequently internally pipped itself, it should be starting to clear out, and no further assistance should be necessary. If the chick has become inactive, the veins/vascular system are looking insipid and vacuum packing has become pronounced then artificial internal pip will be required immediately, (refer to section below).

Vacuumed Membranes: This happens when the membranes are pulled tightly over the chick and chicks' body. The folds of the air cell membrane are extremely tight and folded over on themselves and compressed tightly over the chick, (like a vacuum-packed bag of food with all the air sucked out of it). When dampened, the membranes feel very tight and there is very little membrane movement. In conjunction with poor embryo movement and poorly defined veins, an artificial internal pip is required immediately.

Identify the bill is in the correct position. If it is, the membrane is usually wrapped completely around the tip of the bill. At this level of vacuum packing the veins in the chorio-allantoic membrane are usually very much reduced (fine) as a result of the lack of oxygen. The veins around the tip of the bill can be non-existent as a result of the pressure from the bill.

If the bill is not evident see the section on malposition (Refer to Appendix 1.2)

Collapsed Membranes: Can occur in an egg due to problems during transportation. On occasion it can be genetic, where eggs from the same pair of kiwi have previously had collapsed membranes. Or more often, as a result of vacuum packing. The membranes are under so much pressure that they will be pulled away from the shell membrane and collapse over the top of the chicks body.

If you have a collapsed membrane:

- Stop turning the egg.
- Closely monitor the egg's progress, it might not be necessary to put in an artificial internal pip (Art I.P.) immediately.
- But, if movement dips and veining deteriorates, then consider a view hole and potentially an Art IP.

  Remember that it will be more difficult for the egg to IP as the membranes are not taut and it will be tougher for the bill to pierce through a saggy membrane.

1.1.8 Making an Artificial Internal Pip

- Identify the area where the hole in the membranes is to be made. Dampen the inner shell membrane to help identify where the veins are. The hole should be made just below, or to one side, of the bill. Avoid active veins.
- Using sterile tweezers put a small tear, (2 millimetres), in the inner shell membrane only, so as to expose the chorio-allantoic membrane.

Never use scissors to cut the membrane.

- Once the chorio-allantoic membrane is exposed, pin point a clear area between two veins and pierce the chorio-allantoic membrane (CAM). In some cases, the CAM maybe quite stretchy so ensure that the membrane has actually been pierced. Make a small initial hole and check the reaction of the chick.
- If there is no bleed at this point, the hole can be enlarged a little more to expose the whole tip of the bill, (view figure 33). Determine the angle and orientation of the bill as sometimes a chick may not have completely rotated into the hatch position. Make detailed notes.
- If the bill is inaccessible, it may be necessary to increase the size of the view hole. If the chick is malpositioned and the bill is visible but some distance from the original view hole, a second view hole will need to be put in, closer to the bill, rather than extending the original view hole. The aim is to remove as little shell as possible but still achieve an Art IP.

Figure 33. View Hole and successful artificial internal pip through the shell membranes and the chorio-allantoic membrane. (Photo: National Kiwi Hatchery)

If a bleed occurs during the procedure:

- A small bleed (i.e., dots of blood on the cotton bud) will often stop on its own.
- If the bleeding is soaking a cotton bud, apply gentle pressure with a cotton bud to the edge of the membrane. Do not panic and do not take the pressure off the membrane, until the bleeding has stopped.
- If blood begins to pool around the bill you may need to raise the air cell end of the egg to ensure the bill is clear of the blood.

- Once the bleeding has stopped, reassess if the Art IP has been successful. If nothing has changed in the status of the chick and the Art IP is still required, attempt again but away from the blood vessels.
- Once art IP is complete, check the respiration rate of the chick, tape up the view hole, and place the egg back in the incubator. Write detailed notes about the procedure and any observations made and monitor closely.

Figure 34: Obvious signs of a bleed inside the shell (Photo: B. Wilkinson)

1.1.9 Monitoring of Eggs with View Holes

- For artificially IP'd eggs it is essential that the egg is closely monitored to ensure the chick is receiving adequate oxygen, and the egg is 'clearing out'. The vascular system should be looking stronger and chick movement should increase. This can be done by standard candling and observations; you will not need to open the covered view hole.
- Monitor regularly – movement is your key indicator that the egg is ok and then clearing out.
- When the bill is pushed up into the view hole, or the chick has externally pipped elsewhere, this is considered to now be external pip and the tape can be removed from over the view hole.
- If it does not externally pip (XP) the shell, as expected, consider the best timing to remove the tape covering the Art IP, but only when the egg appears sufficiently cleared out and is progressing towards hatching.
- Patience is important – if the clearing out is slower than expected (but movement good) it could also mean that the egg was not quite ready for pulmonary respiration. Try not to keep opening the view hole cover, every time you do you will flood the air cell with more oxygen than would normally be in the air cell.
- If the movement is very poor and there has been no clearing out, you will have to recheck the IP in the membranes to reassess and to make sure that the bill has not moved under the membrane and away from the hole. Or alternatively, the hole in the membrane may have been too small and has resealed. If this is the case, a new hole will need to be made in the chorio-allantoic membrane.

1.2 Chick Malposition during Hatching

The incidence of malpositioned chicks is very low. Badly malpositioned chicks may be identified due to the unusual positioning of the embryo seen during candling, abnormal location of waste deposits or a strong yolky glow in the wrong area. A classic sign of malposition is the NACE being black where there should be a yolky glow. If just the head of the chick is malpositioned it is difficult to pick this up prior to the chick trying to internally pip.

The two more common embryonic malpositions in kiwi are when the embryo is rotated in the egg, with the bill located at the opposite end from the air cell (in the non-air cell end or NACE), occasionally chicks will crack or "pip" right through the shell when trying to internally pip in this position. Or the bill is down between the thighs. Embryos in this position are unable to pip into the air cell before hatching and mortality rates are extremely high.

An early (65 days) x-ray can be used to identify if a chick is malpositioned if you are unsure. But the x-ray may need to be repeated when the chick is due to internally pip naturally as the embryo can rotate within the egg prior to and during the hatch process as part of that natural process of hatching. Usually, with this type of malposition, the bill will need to be located using an X-ray and a view hole, and an artificial internal pip will need to be made to ensure the chick gets access to oxygen when it tries to internally pip and start the hatch process. See below for examples of malpositioned chicks.

Figure 35. Chick with bill lying on left lateral line below air cell (Photo: West Coast Wildlife Centre)

Figure 36. Chick with bill lying towards the NACE (Photo: National Kiwi Hatchery)

1.2.1 X-ray of Kiwi Eggs.

- Firstly, review all notes, looking at developmental milestone to ensure the egg age is accurate, but if the indicators show it is in active hatch, then considered action is required.
- If a malpositioned chick is suspected, (based on candling), and a bill cannot be located after a view hole has been put in the air cell, the egg will need to be x-rayed immediately.
- Look for any new discoloration all around the shell as that is often a possible hint to where the bill may be located. This can be obvious without any candling and can appear as a dark smudgy patch. Or a fine XP may be detected by running your hands over the egg.
- Contact the veterinarian immediately and schedule a time for the x-ray, allowing time to package the egg properly for transport.
- On arrival at the veterinarian's make sure that the x-ray plate has the Egg ID label and date on it, and most importantly a right (R) or left (L) label so the correct orientation of the egg during the x-ray can be determined.
- The first x-ray needs to be taken of the egg in the upright position, allow the egg to centre itself (air cell away from you) and then wedge it firmly into place.
- For the second x-ray rotate the egg a full 90° to the right so the left lateral line is uppermost, then wedge the egg in place.
- Place the egg back in the carry box and return it to the incubator as soon as possible. The x-ray results are digitalised and will be e-mailed through to you. If it is a particularly complicated malposition, then review the x-ray on site with the vet so that the next appropriate step can be evaluated and the most effective place to put in the view hole and internal pip can be marked in pencil on the shell. The measurements from the edge of the shell to the bill tip can be added to the x-ray by the vet so that you are better able to identify where the bill is. Further x-rays should not be needed unless it is an extremely unusual malposition.

1.2.2 Viewing Holes to Assess Status in Malpositioned Chicks

- If the chick is not yet ready to hatch, (i.e., large external yolk present and chorio-allantoic membrane still active), and depending on the type of malposition, it may be necessary to re-orientate the egg in the hatcher, so the weight of the chick body is not pressing on, for e.g., the head and neck area.
- Again, before putting in a view hole, re-assess all egg notes and egg characteristics. In the case of a malpositioned chick, a view hole is a lot more difficult than the standard view hole, as they are made into a fully active membrane area and not into the safety of the air cell.
- Remember, if the malposition was detected early and x-rayed early, the chick will continue to rotate as it gets closer to the hatch process starting. A repeat x-ray will be required to accurately identify the new positioning of the bill prior to inserting a view hole in the shell.

- Wash the bench and clean all equipment required with Sterigene. An Art IP kit is usually made up of a small Phillips screwdriver, two sets of fine tweezers, vein clamps etc, all sterilised (autoclaved) and the candler. Also have on hand small phials of saline solution, cotton buds, gauze pads, masking tape and clean mat.
- Re-sanitise hands before commencing any work on the view hole and wear sterile gloves. Use a warmed heat pad to rest the egg on, to prevent cooling.
- Have the x-ray at the correct orientation to the egg and be very clear with where the access hole is to be made, using the x-ray as a guide. Mark the area where the shell is to be opened, and make sure you are comfortable with the orientation of the egg as you hold it, (i.e., ensure that it is not upside down).
- Very carefully tap the shell with the screwdriver until you feel the shell starting to crumble. Take your time at this point, and very carefully remove the tiny shell fragments from off the shell membrane. It is essential that the membrane is not punctured at this stage.
- Once the area is clear of shell, look for grey or brown discolouration of the membrane which may indicate the position of the bill. The bill may be evident as a bump under the membrane. You may even see bill movement or using light pressure with a cotton bud over the shell membrane may confirm a suspected bill if you get pushback.
- Often you will not be able to identify the bill at this point so will need to remove the outer shell membrane to give you more visibility. Carefully peel the thicker outer shell membrane away and then the inner shell membrane to expose the chorio-allantoic membrane.
- You should now be able to see the bill and active blood vessels in the chorio-allantoic membrane. Sometimes the veins can be non-existent because of the pressure from the bill or be discoloured due to pressure from the bill causing tiny bleeds. Nevertheless, you still need to be aware of causing a bleed at this stage.
- If the bill is obvious, put in an artificial internal pip in the usual way, (refer to section above). Make sure that you tear the membrane once you have pierced it. Tearing automatically helps to cauterise, (seal), the blood vessels.
- If the bill is not obvious but you are sure that it is within that region, remove more shell to enlarge the hole in the shell. Leave the chorio-allantoic membrane intact at this stage to see if you can locate the tip of the bill by carefully wetting down the membrane, (using sterile water and a cotton bud). Often it is possible to feel the tip of the bill as a raised bump under the membrane with the cotton bud.
- Do not continue to enlarge the view hole if there is no sign of the bill. Stop, re-assess the x-ray and the 'predicted' location of the bill. A second hole may be required.
- If you are close to the bill and you put a hole in the chorio-allantoic membrane the egg should start to clear out once, there is adequate oxygen available for pulmonary respiration.
- Be very cautious if the bill is close to the yolk sac.
- If the bill is not detected after a second hole is made, a second series of x-rays may be necessary. Note: be clear the x-rays are being interpreted correctly.

- It is essential to tape a gauze pad over the new external pip site initially, to prevent the membranes from drying out and sticking to the chick but also reduce the risk of contaminants entering the IP.
- Depending on the malposition, it may be necessary to reorient the egg position while it is in the hatcher so there is minimal pressure lying over the chick's head. The egg may need to be rotated or propped up using wedges of tissue or foam. Continue to monitor the egg closely.

1.3 Assisted Hatches

Embryos may fail to hatch for many reasons, so it is important to have appropriate protocols to accommodate variations in hatch times for kiwi and very clear guidelines for when to assist with hatches.

There are many points that will need to be evaluated before starting an assisted hatch, some having a higher priority status than others, but it is good practice to discuss all these points with fellow team members so that the most appropriate course of action can be decided for the welfare of the chick.

Priority Points are:

- Activity of blood vessels and appearance and amount of yolk – these are the two main factors in deciding whether to hatch.
- Then there is movement, or lack of, bill push back, faeces in the shell, smell of wet dog etc.
- If there are no active veins and no yolk, then a straight forward assist hatch can be done.
- If there are still some veins and possible yolk present, a hole put in the NACE can help assess status. If the decision is to hatch, then the blood veins can be clamped from that angle.

The next decision to make is how to approach the hatch. There are two methods of assist hatch, the standard hatch starting from the air cell and an assisted hatch via the NACE first.

1.3.1 Standard Assisted Hatch

- The majority of malpositioned chicks will not hatch without some form of assistance. All hatching parameters, (movement, egg colour and glow, respiration rate, vocalisations, sweaty wet chick smell, etc) should be monitored to determine the best time to hatch the chick. While allowing the chick is given as much time as possible to fully absorb the yolk, for the vascular system to shut down, and for the chick to complete the normal physiological processes of hatching. Do not rush the hatch.
- Once the chick is deemed ready to hatch, or alternatively, if the chick becomes very distressed, you will need to proceed with a full assisted hatch.

- Preparation is vital. A minimum of two people is required, although three people is preferable (one to hold the egg/chick, one to carry out the assisted hatch, and one support person to fetch equipment, take photographs, and write up the processes used during hatch in the chick notes).
- Clean the bench where you will carry out the assisted hatch and put down a clean mat. Ensure you have a fresh set of autoclaved instruments for hatching. Set out the saline solution, sterile cotton buds, gauze pads, tape, a pre-warmed heat pad, Betadine cream and spray, the camera, the x-rays, and chick notes.
- Wash and sanitise hands, then wear sterilised gloves. Before starting the assisted hatch, decide on the role of each person, and make sure that everyone is very clear about the procedure that is about to start. Make sure you are fully prepared for any eventuality, (such as a bleed, large external yolk, etc) and remain calm. It might be an idea to let the vet know in advance too.
- Re-candle the egg before you start to familiarise yourself with the position.
- The person hatching the egg rests the egg on the heat pad, and then begins by enlarging the external pip area within the air cell to expose the head. Chip off only the shell around the air cell and keep the membranes intact.
- As the shell is removed, the membranes are more malleable and, using a cotton bud, you can physically lift the membrane to view the navel area. If you see lots of external yolk, and you feel the chick can continue to absorb it, it is not too late to stop and re-assess the hatch. You can patch or tape the chick back into the shell for another few hours, but close monitoring is required, to make sure the chick does not become too stressed.
- If no yolk is obvious, continue with the hatch. Remove the shell over a larger area, exposing the back of the neck and down towards the abdomen. Once there is a quarter to a third of the shell membrane exposed, peel this back and expose the chorio-allantoic membrane. Continue to try and see if there is external yolk. Once this stage is reached the hatch must continue. Remove the chorio-allantoic membrane and monitor for bleeding.
- If excessive bleeding begins you will need to progress quite quickly, so you can clamp the main umbilical vein and artery as soon as possible to prevent excessive blood loss (see below Navel Bleeds). If bleeding is minimal, (or non-existent), continue removing the shell at a steady pace.
- When possible, lift the head and bill up as this usually helps expose the navel. If the yolk is internalised, and there is no bleeding, gently remove the chick from the shell, clamp and then carefully rip (with your fingers) the umbilical vein (see below for clamping veins).
- Spray the navel with Betadine as soon after hatch as possible. Weigh the chick and place it back into the hatcher immediately to avoid it chilling. See below if there is a navel bleed.

Figure 37. Standard Assisted Hatch, from the aircell. Note the white inner shell membrane showing vacuum packing, but also no obvious problem is the lack of a bill where it should be positioned in the aircell area. (Photo: National Kiwi Hatchery)

1.3.2 Assisted Hatch Via the NACE

- Follow the first six points from above.
- If you have any doubts about a small external yolk or external umbilicus, then it would be more appropriate to hatch starting at the NACE.
- Candle the NACE and mark on the shell in pencil, the best place to make a view hole to assess the navel. Position this VH between the hocks, so you don't end up with the hocks or legs smashing out.
- Create a hole through the shell, damp the outer shell membrane with saline solution, then gently peel both the outer and inner shell membrane away revealing the CAM membrane. This will give you an excellent indication of how active the blood vessels are. Carefully pierce the CAM membrane, opening it so that you can view the chicks navel, the position of the legs and the presence of any faecal matter.
- If you see lots of external yolk, and you feel the chick can continue to absorb it, it is not too late to stop and re-assess the hatch, even waiting a short period of time can have a strong effect on the amount of yolk internalised. You can patch the shell or tape the chick back into the shell for another few hours, but close monitoring is required, to make sure the chick does not become too stressed.
- If there is no yolk, then you can continue to hatch the chick. When hatching this way, it is very easy to clamp the blood vessels before you start to hatch the chick out thus avoiding a navel bleed (see clamping umbilical veins). Spray the navel with Betadine as soon after hatch as possible, weigh and return to the hatcher, to avoid it chilling.

Figure 38. Assisted hatch via the NACE, with the navel vein being clamped. Chick malpositioned as bill is positioned below the aircell line. (Photo: National Kiwi Hatchery)

1.4 Clamping the Umbilical Blood Vessels

- This can be achieved more easily if you have gone in through the NACE, while the chick is still in the hatch position and the legs are still in the shell. In this situation the legs are fixed and are not a complicating factor in accurately clamping the veins. See Figure 38 Vein clamped while insitu in egg.
- If completing a standard assisted hatch. Two people are essential to continue with this process as the chick must be firmly restrained to prevent leg movements from rupturing these veins. The chick should be resting on a heat pad and held quite still. Locate both the umbilical artery and vein running out of the navel, (located side by side). Carefully clamp this as far away from the navel as possible. Do not pull the clamp in any way and keep it clamped shut until the bleeding has stopped. If for some reason, bleeding restarts you will need to re-clamp, but lower down towards the navel.
- It is essential to hold both legs firmly, but this can be extremely difficult if the chick is very 'wriggly' and kicking out with the legs. If the blood vessels do break and cannot be re-clamped, refer to the notes below for navel bleeds.
- It is important with both hatch systems, to spray the navel with Betadine as soon as possible.

1.4.1 Navel Bleeds

A small bleed from the navel will often stop on its own and can be considered a normal part of hatching, it is nothing to get too concerned about. But occasionally, towards the end of an assisted hatch, you will have a blood vessel that breaks inside the navel, making it almost impossible to clamp and the navel will keep bleeding, without wanting to stop. This procedure can be extremely difficult when the chick is very 'wriggly' and kicking out with the legs. So the person holding the chick will need to hold the legs firmly too.

In this situation follow below:

- If the blood vessels do break and cannot be re-clamped, immediately place a Telfa pad (non-stick) over the navel and press. Hold the chick upright, so the blood can exit the navel as opposed to pool inside it and use the weight of the chick on your hand as pressure until the bleeding stops.
- Do not keep looking, keep pressure on the navel and add extra pads as required, these can be absorbent pads, as long as the inner pad is non-stick.
- A bleed should stop within 20mins, if not you should contact your vet for advice, but still continue with pressure.
- Remember to hold chick upright – extended periods on back puts pressure on their air sacs.
- Ensure the chick does not get too cold – do this in a still air incubator if available. The chick can be placed upright, in a small donut so the chicks weight can provide the downward pressure on the navel – monitor the chick to ensure it doesn't roll over, off his navel.
- Supportive care.
- If significant blood loss, discuss with vet and consider oxygen support if

increased respiration rate / laboured breathing, at this stage, do not worry about dehydration, as over hydration is a risk and young chicks are particularly good at replenishing blood. Check mucous membranes within 20-30mins, if pale and laboured breathing start oxygen support. If nice pink colour, hold off and monitor.

1.5 External Yolk or External Umbilicus

If you have external yolk, it is extremely likely that you will have an active chorio-allantoic membrane making clamping of the umbilical veins and arteries vital.

1.5.1 Internalising an External Yolk

Putting in a view hole at the NACE with an assisted hatch, will help avoid hatching a chick that still has a small amount of external yolk. But a chick can hatch naturally with an external yolk. If caught soon after hatch, it should be possible to internalise it manually. Quite large yolks can be internalised if found early enough. But if it is a very large yolk sac then vet assistance will be required. Remember, hygiene is essential and sterile gloves must be worn ALWAYS.

- By gently using your fingers, (pressure pads, cotton buds), to surround all sides of the yolk encased within the vitelline membrane and yolk sac membrane, place a constant, firm pressure to manipulate the yolk into the abdominal cavity.
- There is only a small window of time to complete this, (~20 minutes post hatch), before the ring of abdominal muscle will close the navel area making it impossible to internalise the yolk (see figure 40).
- If there is any sign of faeces over the yolk, this should be carefully removed, and the yolk sprayed with Betadine. The yolk will internalise with a constant gentle pressure. But too much pressure can rupture the yolk sac membrane, and this will mean the chick will need to be euthanised.
- Once most of the yolk is internalised you can use a clean cotton bud, liberally covered in Betadine cream, to gently manipulate the last of the vitelline membrane, and the umbilicus into the navel hole.
- As soon as this is completed, squeeze the navel ring together and apply a constant downward pressure to the umbilicus for at least 2 to 5 minutes (up to 10 minutes). The navel should remain closed. Check the area regularly and make sure the chick is not chilling. It is usually fine if the chick is on a warm heat pad and surrounded by warm hands.
- Apply more Betadine, (spray or cream), weigh the chick and quickly check the post hatch position of the legs, (extremely important in malpositioned chicks). Then place the chick on its' abdomen in the hatcher with a gauze pad over the whole navel area, so that there is continued pressure on the umbilical area. A small donut can be used to ensure the chick stays upright, resting on its navel.
- It may be necessary to maintain the hatcher temperature at 34.0°C for a longer period of time, and if the chick is having difficulties thermo-regulating or is extremely tired, the temperature may need to be increased slightly. But monitor the chick carefully so as not to risk heat exhaustion, especially as they can't move away from the heat source.

Figure 39. External yolk being manually internalised (Photo: National Kiwi Hatchery)

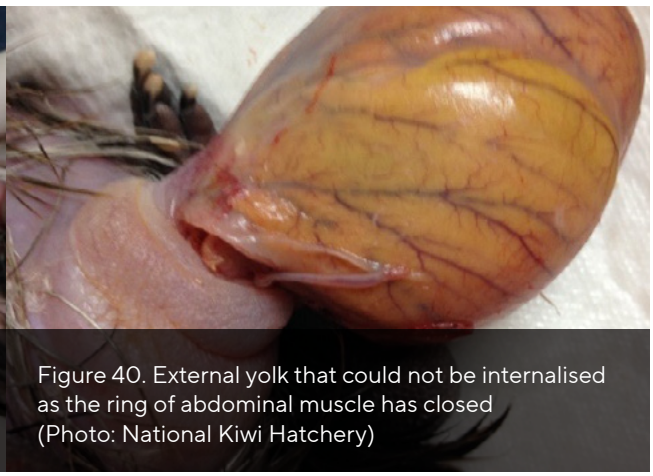

Figure 40. External yolk that could not be internalised as the ring of abdominal muscle has closed (Photo: National Kiwi Hatchery)

1.5.2 External Umbilicus

Occasionally a chick hatches where the umbilicus has not been fully internalised. This is called an external umbilicus; it can vary in length from 1 to 3 centimetres and appears very 'meaty' or fleshy.

- If staff are present at the time of hatch it may be possible to internalise the umbilicus before the ring of abdominal muscle will close the navel area, in a similar way to the external yolk. There is only a small window of time to complete this post hatch, (~20 minutes).
- As outlined above, use gentle pressures with a cotton bud soaked in Betadine cream, and gently fold the umbilicus back into place. Make sure the umbilicus is clean before commencing the procedure.
- If it is too late to internalise the umbilicus, it is not too big a problem as it will dry, become black in colour, shrivel and eventually, drop off. Generously cover the umbilicus with Betadine cream, to protect the area from infection, and leave it. Close monitoring will be essential. Any sign of redness or infection will require the chick to been seen by a veterinarian, and likely a course of antibiotics will be prescribed.
- Chicks that have had an assisted hatch or external umbilicus will need careful monitoring for the next three weeks in case of additional yolk sac problems, or umbilical/naval stalk infections.

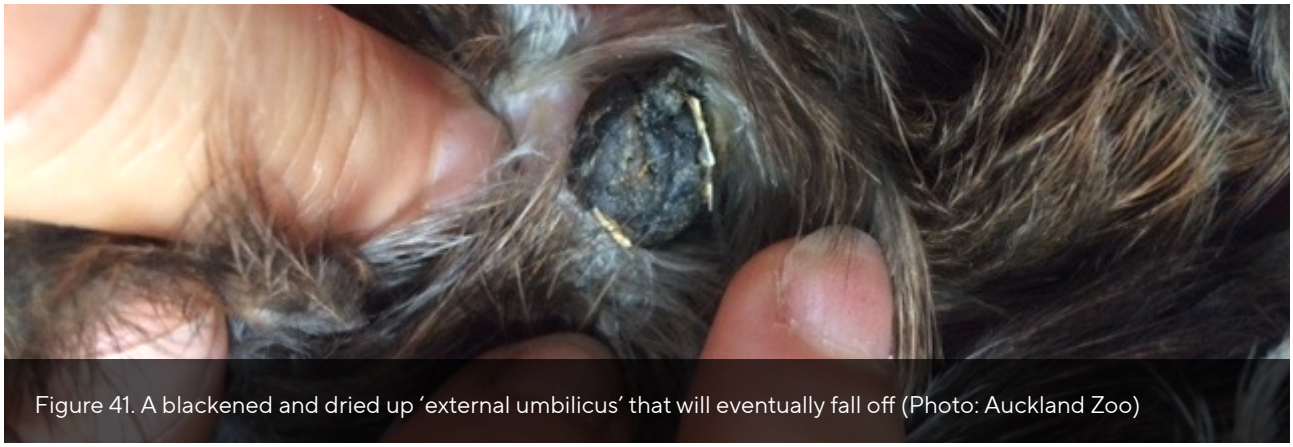

Figure 41. A blackened and dried up 'external umbilicus' that will eventually fall off (Photo: Auckland Zoo)

2. Correction of Malpositioned Legs

Sometimes kiwi chicks are affected with splayed or rotated legs. This may be a result of a malposition in the egg, incorrect incubation parameters being used, a fall resulting in injury to the leg or slipping on a smooth surface in the hatcher or brooder.

Splayed legs are often preventable by the use of appropriate substrate during the first week after hatch, usually brooder matting to provide a non-slip surface.

Seek veterinary assistance if a chick has hatched with splayed or rotated limbs or any physical deformities.

A veterinarian should be consulted before any hobbling procedure is carried out to confirm diagnosis and appropriate treatment.

If, when handling the chick post hatch, it is apparent the legs, (specifically the lower tarsometatarsus), are not evenly spaced and at the correct angle from the hip and femur, applying hobbles may be necessary. Do not hobble the legs immediately after the chick has hatched no matter how serious the problem is. Instead, re-examine the orientation of the legs after 2 to 3 hours. It is important that the chick is allowed time to rest, recover and become active after hatching.

Figure 42 and 43. A malpositioned chick that requires a hobble or spacer to realign the leg (left). The legs shown with the spacer attached to both legs (Photo: National Kiwi Hatchery and S. Bassett)

If the hatch occurred in the late afternoon, leave correction of the limb alignment until the morning. If the chick hatched during the night, hobble the legs the following morning.

If problems with splayed legs are not addressed quickly, (i.e., within 24 hours), they can lead to long term leg problems such as permanently splayed legs, tibiotarsal rotation and perosis, (tendon slipping off the back of the hock). This may result in euthanasia when the chick gets older.

Severe leg deformities should be referred to Massey Universities Wildbase Hospital for assessment and treatment options.

Two people are required to carry out the procedure to put the spacer (or hobble) on a chicks legs. The procedure is outlined below:

- A spacer is basically a stiff piece of card, or several layers of vet wrap tape that form a firm divider to keep the legs at the correct angle and space apart. There are a variety of types of spacers made from various materials for example cut out foam, to stiff card. From vet wrap to masking tape. A firm spacer is essential when one of the legs is positioned inward towards the navel, (midline, refer to Figure 42). But it must not be so hard it causes rubbing or blisters on the soft scales of the chick's leg.
- Once made, the spacer is attached to loops of tape which goes around the chicks' legs. The tape must be folded over on itself, so it does not stick to the leg.
- The legs are hobbled just above the foot joint, (lower tarsometatarsus), (refer to Figure 43).
- It is important to make sure the spacer is the correct size and length for the individual chick. A spacer that is too small will pull the legs inwards too tightly, and a spacer that is too long will push the legs apart too far. This will subsequently have a direct effect on tendon development.
- Hold the chick on its back and line the legs up in the correct position, (to determine the correct spacer size). The person holding the chick can then maintain the legs in the correct orientation while the spacer is being attached. It is important to attach the spacer to one leg and double check the size, before attaching the spacer to the second leg. Several attempts may be necessary to determine the correct size of the spacer.
- Do not attach the loops around the legs too tightly. They should slide up and down the leg and not cause rubbing.
- It may be necessary to place a second spacer above the hock joint to keep the hocks in line, but this is rare and only necessary in very severe cases.
- If the legs are taped early enough, the hobbles/spacer should only need to stay on the chick for 24 to 48 hours, (this time is determined on an individual chick basis). But by this stage the tendons are stronger, there is even weight on both legs as the chick is crouching, and legs should now be in line. Check the tape regularly for rubbing and loosen the loops if rubbing is likely.

- It is vital that leg position is closely monitored in the brooder when the chick is crouching more and becoming more mobile. The hobbled legs need careful monitoring for an improvement in the correct leg angle.
- Once the chick appears to be holding the legs in the correct position, the tape and/or spacer can be removed, but the chick will require continued monitoring of the leg position for the next week. This often coincides with the full health check at five days of age.

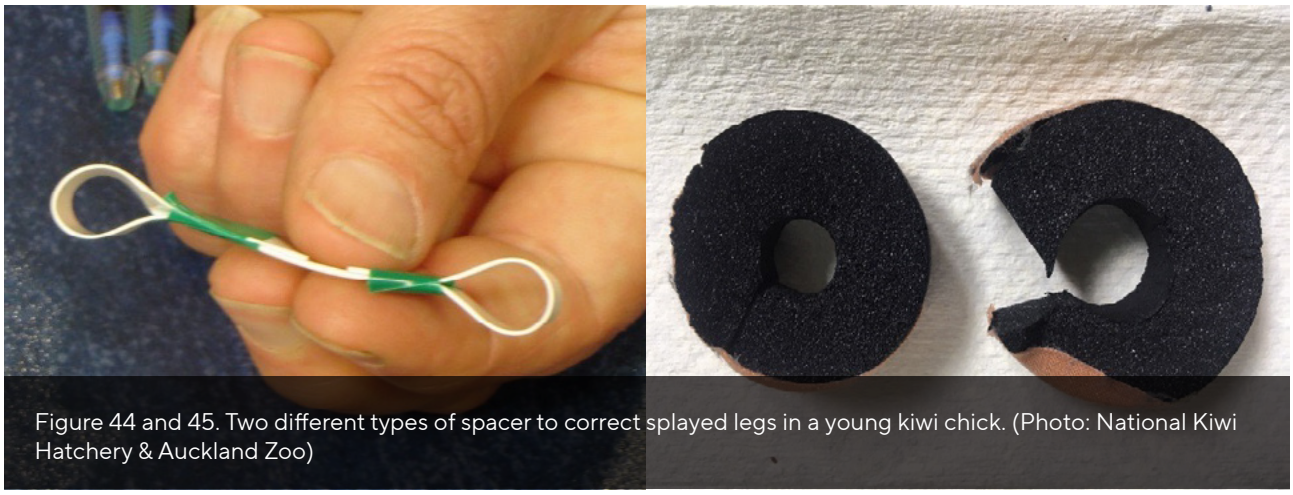

Figure 44 and 45. Two different types of spacer to correct splayed legs in a young kiwi chick. (Photo: National Kiwi Hatchery & Auckland Zoo)

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