6.1 i Cassowary Gate Trial 2009 Ella Bay

ELLA BAY
Far North Queensland

Report on

Cassowary Escape Gate Trials

At

Johnson River Crocodile Farm

December 2009 Revision 1



Abstract

Habit loss, fragmentation and road traffic are the primary threat to the survival of the endangered Southern Cassowary (*Casuarius casuarius johnsonii)*. Mitigation measures against road deaths include directional fencing and safe crossing points. Successful implementation, of these measures have so far been encumbered by the lack of an effective escape mechanism such as a one way gate which allows safe exit for cassowaries inadvertently trapped within a road corridor.

Ella Bay Developments has designed and developed a one way escape gate, to include in tensioned shadecloth directional fencing. The escape gate concept is a series of opposing hinged fingers which form a funnelling valve that permits easy passage from one side and difficult or no passage from the other side. The gate comprised a pair of ten sprung HDPE 'fingers', specifically designed for the anatomy of a cassowary.

The gate was trialled at the Johnstone River Crocodile Park, Queensland with two adult male cassowaries which had been reared in captivity. The cassowaries used the escape gate to access their food over a month and continued to use the gate preferentially during a number of trials even when provided with an alternative access point. The gate was reversed and the cassowaries were unable to move through the gate in the wrong direction. There was no photographic evidence or observations of birds moving through the gate from the opposite direction or of any physical harm to them.

The trials demonstrated a successful strategy of using a shadecloth funnel entrance as a visual cue to the gate and a one way escape gate. While the motivation for the captive cassowaries to use the gate was provided by their feeding station, the use of the gate by wild cassowaries will only be obtained through future in situ observations.

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1. Introduction

The southern cassowary, (*Casuarius casuarius johnsonii*), is a large flightless bird found in north Queensland Wet Tropics and Cape York. The species is currently threatened with extinction due to a range of impacts, primarily related to anthropogenic factors (habitat loss/fragmentation, dog attack and vehicles).

The National Recovery Plan for the Southern Cassowary (Latch, 2007) has identified roads and traffic as one of the key threats to the survival of the species. Roads lead to high levels of mortality through vehicle impact, as well as fragmenting habitat and creating barriers to cassowary movement. Thousands of kilometres of roads intersect cassowary habitat in the Wet Tropics making it necessary for the birds to cross roads to forage and/or breed. Usually solitary animals, cassowaries live in a home range of up to 3-5km² that fluctuates depending on season and availability of food while female cassowaries tend to have overlapping ranges with several males (Moore, 2007).

Current data on cassowary road strike comes primarily from Mission Beach (Qld) where the rainforest and consequently home range areas are intersected and fragmented by roads. Between 1989 and 1998, around 40 cassowaries were killed on roads in the Mission Beach area (Francis and O'Malley, 2008). A further 28 birds were killed on these roads between 2001 and 2005 (Latch, 2007). Substantial measures have been undertaken to mitigate these deaths, including the use of signage, some modification of culverts, the integration of short sections of fencing and traffic slowing measures such as the installation of line markings and rumble strips. However, cassowary road mortalities continue to occur at Mission Beach, with four known road deaths in 2008 (Francis and O'Malley 2008).

These road mortalities are likely to significantly impact on the recovery of the southern cassowary. The species is long-lived, slow-reproducing with lengthy parental care and low juvenile survival. As a result, each road death of an adult bird may potentially influence population dynamics and the population's reproductive fitness (Bentrupperbäumer, 1998 Cited in Buosi & Burnett 2007). Effective road management within areas that support the cassowary is therefore an imperative of cassowary conservation. As demonstrated in the Mission Beach area, effective strategies to avoid or minimise cassowary road deaths are yet to be developed or implemented.

The impacts of roads on wildlife are well documented in many other parts of the world. Road mortality has significantly impacted species such as the white-tailed deer (Odocoileus virginianus), Florida panthers (Puma concolor coryi), and black bears (Ursus americanus) (Puglisi et al. 1974; Maehr et al. 1991). Wildlife related road accidents are also a serious safety concern for people. For instance, in the upper mid-west of the United States, more than 125,000 deer-vehicle accidents are reported each year, causing more than 30 human fatalities and 4,700 injuries (Knapp et al, 2004).

Numerous methods have been developed in these countries to effectively reduce road-related wildlife mortality (Clevenger et al, 2007; Huijser, et al 2007). One such strategy involves the use of safe road crossing opportunities such as underpasses or overpasses, allowing the animals to continue to move within the landscape, thereby avoiding habitat fragmentation. These safe crossing points are used in conjunction with directional fencing, which acts to keep the animals from entering the road reserve while guiding them towards the safe crossing points.

One of the issues associated with directional fencing is inadvertent fauna entry into the road reserve and prevention of escape by the fencing. A range of mechanisms have been developed and trialled for fauna escape. For instance, jump-outs or earthen escape ramps have been used along roads; while in the Canada and the United States considerable effort has been invested in the design of one-way gates for moose, deer and elk (Sielecki, 2007).

While the use of fencing and safe crossing points is not a novel concept in Australia for the mitigation of cassowary road deaths, implementation has been encumbered by the lack of an effective escape mechanism (Scott, 2009).

This paper presents the results of a preliminary study trialling the design of a one-way escape gate for use by cassowaries in association with directional cassowary fencing. This escape gate has been developed based on the design principles reported in Sielecki (2007). Significant modifications were required to the design of the gate to accommodate the size, shape and movement characteristics of a cassowary. The primary aim of this research was to determine whether adult cassowaries would voluntarily use the one-way escape gate when motivated through feeding.

2. Method

Escape Gate and Directional Fence Design

The overall concept of the escape gate is a series of opposing hinged fingers which form a funnelling valve that permits easy passage from one side and difficult or no passage from the other side. The escape gate design for cassowaries evolved from analysis of Canadian research for moose and deer (Sielecki, 2007) and one way spear gates commonly used with cattle and sheep in Australia. All of these gates are manufactured from steel, with a focus on minimising destruction of the gate. The Canadian gate for example was constructed from ganged metal tynes from agricultural equipment.

The design of the gate for cassowaries was modified specifically to take into account the different anatomy and behaviour of the birds. Cassowaries are more susceptible to injury with their long necks, non-functioning wings and high risk of infection through leg scale grazes (Romer, 1997). Cassowaries are also naturally inquisitive yet cautious; when crossing through a wire fence or restriction the birds are timid, often testing the opening size and feel many times before entering. Cassowary chicks are small, fragile and the size of a domestic hen; they closely follow behind their fathers and become stressed if isolated.

The gate comprised ten 'fingers' curving out from each side of the frame on spring loaded hinges that restrict movement to one direction. The fingers of the cassowary gate were fabricated from UV stabilised High Density Polyethylene (HDPE), which was smoothly cut and rounded to avoid any sharp edges that could snag and featured an integral ball end to prevent impalement. To cater for differences in function the fingers of the cassowary gate were designed with a different cross section in the vertical and horizontal plane, with the horizontal plane tapering to a smaller cross section at the ball allowing the tip of the finger to bend more easily in the horizontal plane. Additionally the fingers of the gate were individually spring loaded to allow for different sensitivities on contact with the birds. This provided a range of movement from a small 0.5N force at the ball end finger tips to 2N at the shoulder contact point with the springs requiring 5N at the point of spring flex. The force required to bend the fingers and open the gate was initially a small force as the flex was taken up by bending of the HDPE finger material and then the force progressively increased as the spring engaged and the fingers opened sufficiently to allow the cassowary through. The lower fingers were set up with a smaller spring tension to ensure that younger cassowaries (subadults and chicks) were not inhibited from entering and that the cassowaries' legs were not bruised.

Figure 1: Specifications for the cassowary one-way escape gate

The gate was constructed to fit inside a 1.8m high tensioned shadecloth directional fence (Figure 2). The outer frame opening was 1.5m wide providing a theoretical maximum visual window of 1.8m x 1.5m. The gap between 'fingers' both vertically and horizontally could be adjusted in the trial to optimise the 'clear line of sight' for the birds to encourage entry. Initially the gap was set 100mm between the ball ends of the fingers. Visually the gate was designed to appear as open as possible; particularly in contrast to the shadecloth fence on either side. Figure 1 shows the food trough is clearly visible through the gate.

Typically, directional fencing is 1.8m to 2.4m high using wire cyclone mesh fence material. This open mesh fence does not provide a significant differential appearance between the fence and the escape gate. Also the type of fencing is not suitable for all fauna with the potential for harm being caused by trapped/snagged limbs. Cyclone fencing has been used with cassowaries in a number of places with negative results leading to injury and possible death. The directional fencing used in the trial was based on shadecloth having a shade factor of 50% to restrict the visibility of the bird through the fence and enhance the visual cues of the escape gate. The shadecloth was also chosen due to its soft impact to minimise injury to the birds. The fence was constructed with a local funnel arrangement into the gate frame to focus the birds as they moved along the fence (Figure 2).

The trial site was established within a corner of the enclosure which included the only feeding station for the birds. It created a small internal yard, triangular in shape, bound on two sides by the existing chain wire fence, with the third side consisting of the constructed 1.8m high shadecloth directional fence which incorporated the one way escape gate.

Figure 2: Photo showing the 'trial area' within the cassowary enclosure, feed station on the left

Study Site and Animals

The study was undertaken at the Johnstone River Crocodile Park in Innisfail, Queensland. The staff conducts daily guided tours where, in addition to the crocodiles, the visitors can view a variety of iconic Australian fauna. The two adult male cassowary trial subjects are housed in a large enclosure within the park and are named Wally Bubble (due to the distinct shape of his casque) and Henry. Both birds were reared in captivity having been rescued as young orphaned or injured chicks. They were both found locally, indicating that they are from the local Graham-Seymour Range cassowary population. It is estimated that they are between 16 to 20 years of age. Wally arrived at least one year prior to Henry and is the larger of the two birds however no dominance or hierarchy has been observed in their behaviour.

Study Methodology and Data Collection

Cassowary use of the one-way gate and directional fencing was tested on Wally and Henry for 30 days from the 6th of August 2009 to the 4th of September 2009.

Within this time four (4) trials were conducted:

- Trial 1: One-way gate allowing access to the enclosed yard trial area;
- Trial 2: Repeat of Trial 1, plus a section of the fencing left open as a second entry/exit point;
- Trial 3: Repeat of Trial 1, with the one-way gate reversed preventing access to feeding; and
- Trial 4: Repeat of Trial 2 following reversal of the gate.

For all four trials, the method of observation and photographic recording involved the use of up to three Reconyx digital infrared cameras mounted in the alternate positions shown. The cameras are activated by motion sensors and operate during the day and at night, with an infrared flash. They were set up in one of four positions around the gate to record the number

of times the cassowaries entered the gate, as well as to study and capture their behaviour in relation to the gate and along the fence (see Figure 3).

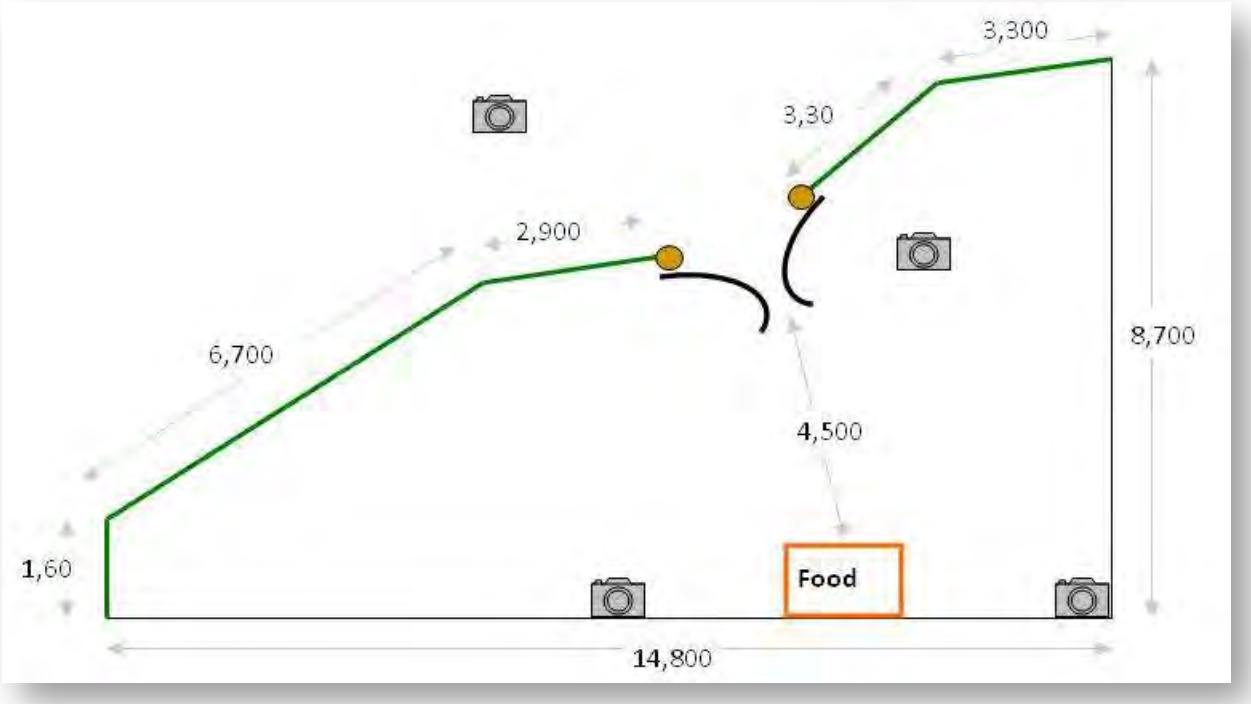

Figure 3: Trial 1 set up showing the directional fencing (green), and the one-way gate enabling the cassowaries access to their food.

The cassowaries were monitored throughout the day by staff at the Johnstone River Crocodile Park (JRCF) and were also observed for up to one hour each day by the Ella Bay Environmental Team (EBET). This was to ensure no safety issues arose, and any notable behaviour recorded.

Trial 1: One-way gate allowing access to the enclosed yard trial area

The primary aim of this trial was to determine whether a cassowary could and would voluntarily use the one-way gate. As illustrated in Figure 2 and 3, the fence and gate were constructed around the cassowaries' only feeding trough. They are routinely fed fresh seasonal fruit every morning around 8am. This practice was continued throughout the full period of the trials with the food being replaced everyday. It was identified prior to the trial that food would be the motivational factor as no other practical options were available, suitable or free of harm. The layout and specifications of Trial 1 are shown in Figure 3 illustrating the locations of the Reconyx motion cameras, all of which were positioned to point at the one-way gate.

Trial 2: Repeat of Trial 1 plus a section of the fencing left open as a second entry/exit point

The second trial was set up the same as the first, however an alternative access point to the food trough was provided (as shown in Figure 2 and 4). This access point was the means by which the cassowaries were removed from the test area in Trial 1. It was located on the edge of the constructed shadecloth fencing, which was unsecured from the chain wire fencing and drawn back 1.6m along the tension wire and secured back to the post. The purpose of this trial was to determine how the cassowaries would behave when faced with two different means by which to enter the trial area.

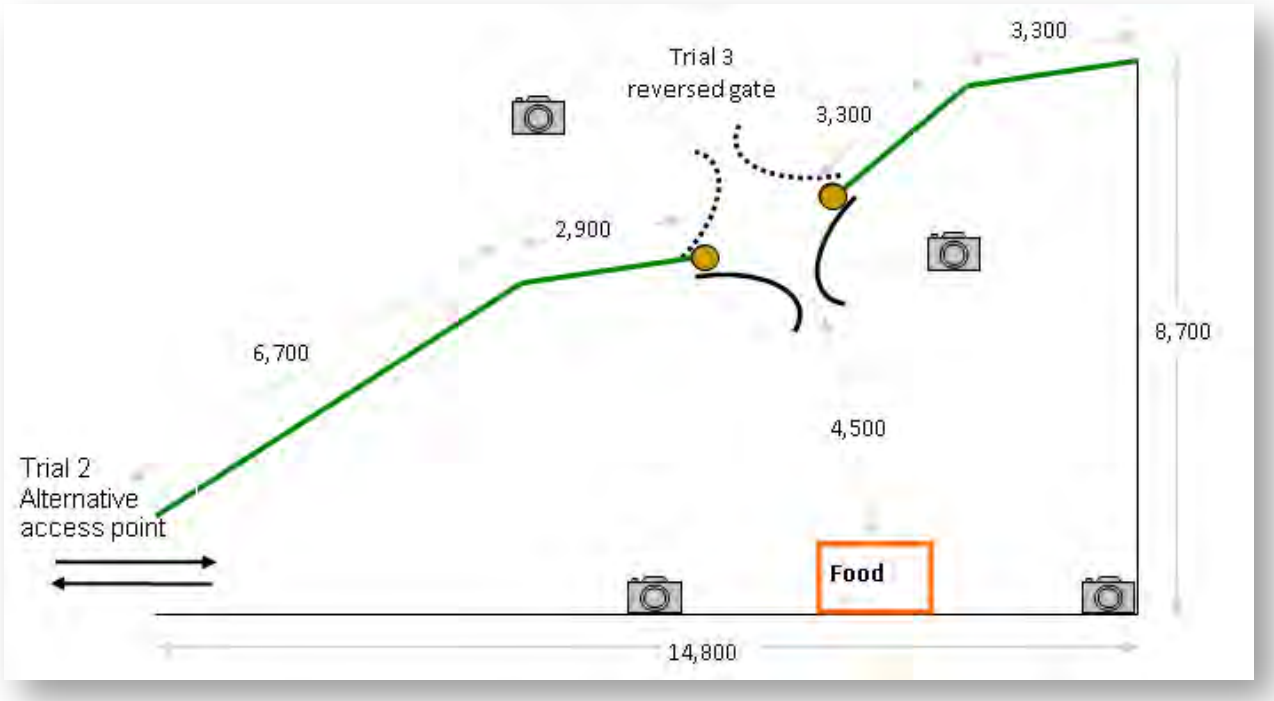

Figure 4: Trial 2 set up showing the alternative access point provided and trial 3 with the reversed gate.

Trial 3: Repeat of Trial 1 with the One-way gate reversed preventing access to feeding

During the third trial, the set up for the first trial was repeated (with no second access point available); however in this case the one-way gate was reversed. This trial aimed to determine whether the cassowaries would attempt to enter the gate in reverse to gain access to their food, thereby testing the efficacy of the gate in precluding access in the wrong direction. The layout and specifications of Trial 3 are shown in Figure 4.

Trial 4: Repeat of Trial 2 following reversal of the gate

During the fourth trial, the set up for the trial 2 was repeated with a second access point available. This trial aimed to determine whether the cassowaries would be discouraged from attempting to access the gate following refusal in Trial 3. The layout and specifications of Trial 4 are shown in Figure 4.

3. Results

The one-way escape gate was tested on two male adult captive cassowaries, Wally and Henry at the Johnstone River Crocodile Park for 30 days between 6th August 2009 and 4th

September 2009. Altogether, there were 88 photographic records of the cassowaries entering the one-way gate. Of these, there were similar records of either bird entering the gate, suggesting that neither bird was more disposed than the other to use the gate. Initially only one camera was installed, which had difficulty obtaining images of the birds within the gate area due to a time lag on firing and suffered from continual battery failure. Further cameras were installed during trial 2 however a total period of 7 days was not photographically recorded. Taking into account an average of 4 entries per day during this period the total usage would have been greater 116 passages through the gate.

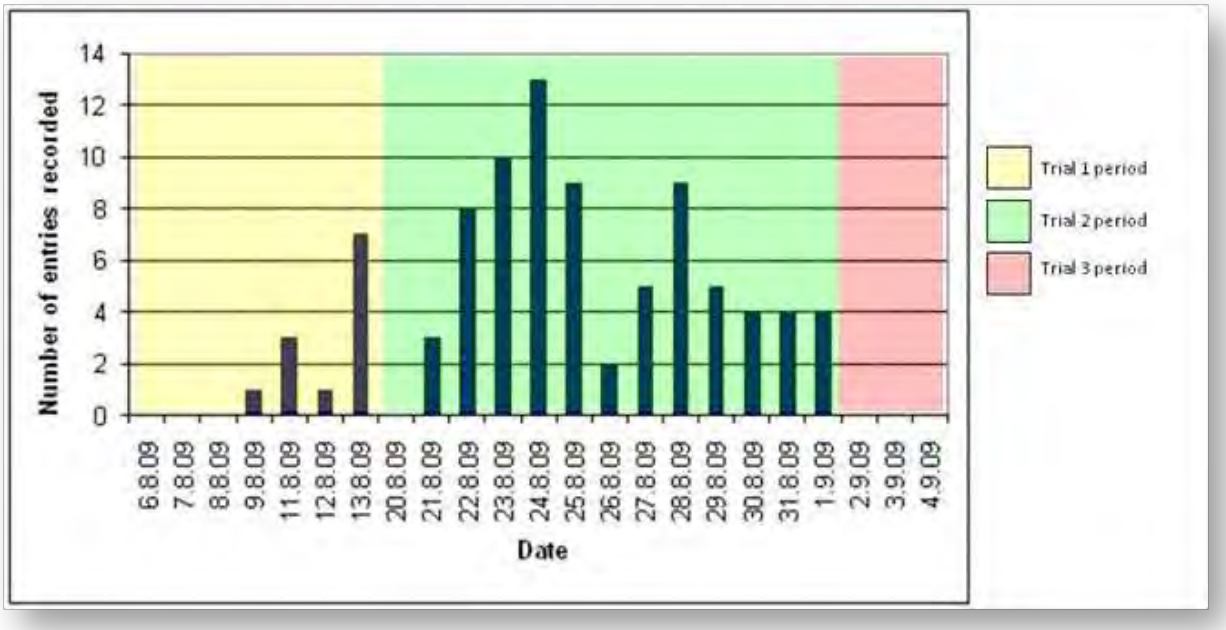

Figure 5: The number of gate entries recorded on each day that data was obtained. No pattern was observed in the frequency of use of the one-way gate over the period of the first two trials.

Trial 1: One-way gate allowing access to the enclosed yard trial area was conducted over seven days between 6 August 2009 and 13 August 2009. Twelve (12) photographic records of the cassowaries entering the one-way gate were obtained during this trial.

The fence and gate were set up in the enclosure by around 2pm on 6 August. Both Wally and Henry were observed within minutes following the fence line and inspecting the gate. The directional fencing and localised funnelling into the gate area functioned well, leading the birds towards the opening of the gate. This behaviour is illustrated in the series of photos shown in Figure 6.

Figure 6: Series of sequential photos (07.08.09) demonstrating the directional function of the fencing leading Henry towards the one-way gate entrance.

Both birds appeared reluctant to use the gate during the first two days. On 7 August 2009 Wally attempted to enter the gate. However, he withdrew before passing through, as shown

in the series of photos in Figure 7. Discussion of this behaviour is addressed in the following section.

Figure 7: Series of sequential photos (07.08.09) showing Wally attempting to enter the gate and then withdrawing.

The birds were hand fed once during the second day to maintain good health. However, both birds only ate a small amount, which suggests they were not particularly hungry.

On 9 August 2009, the gate was modified to encourage use by the cassowaries. The pair of fingers in the fourth row were removed to create a visual window for the birds. In addition, the gap between each pair of fingers (shown as the horizontal space between opposing fingers in Figure 1) was widened from 100mm to 200mm, again, creating a better visual window to encourage entry. Three minutes after these adjustments were made, Henry entered the gate. This first entry occurred 66 hours after the gate and fence were initially installed around the cassowaries' feeding trough.

Figure 8 shows the first gate entry. As can be seen by Henry's position as he entered the gate, his head and neck remained well below the gap created by removal of the fourth pair of fingers. This indicated that it was the widening of the horizontal space between opposing fingers to 200mm, rather than removal of the pair of fingers which encouraged the entry.

Figure 8: Photo (09.08.09) showing Henry entering the gate for the first time. Note his head and neck entry position well below the space created through removal of the fourth pair of fingers.

The fourth pair of fingers was reinstalled after one hour. The cassowary's continued use of the gate after this provided further support for the importance of the horizontal space between opposing fingers in stimulating entry.

Trial 2: Repeat of Trial 1 (One-way gate allowing access to the enclosed yard trial area) plus a section of the fencing left open as a second entry/exit point was conducted over nineteen days between 13 August 2009 and 1 September 2009. Seventy-six (76) records of the cassowaries entering the one-way gate were obtained during this trial. It is possible that the cassowaries accessed the area through the open fence as the birds would follow staff through the open fence but there was no photographic evidence all observations of the birds moving through from that direction.

These results indicate that the birds:

- Were not averse to using the one-way gate; and
- Would preferentially use the gate even when provided with an alternative access point.

The series of photos in Figure 9 show Wally entering the one-way gate and exiting the food enclosure via the alternative access point.

Figure 9: Series of sequential photos (02.09.09) showing Wally entering the one-way gate and exiting via the alternative access point.

Trial 3: Repeat of Trial 1 (One-way gate allowing access to the enclosed yard trial area) with the One-way gate reversed preventing access to feeding was conducted over three days between 1st September 2009 and 4th September 2009. The cassowaries were not observed entering the gate during this time. The birds would approach the gate and move to either side of the centre and line up to try the gate at the sides.

The birds were hand fed once during the second day of this trial to maintain good health and replicate the conditions from the first trial.

Trial 4: Repeat of Trial 2 (Repeat of Trial 1: One-way gate allowing access to the enclosed yard trial area; plus a section of the fencing left open as a second entry/exit point) following reversal of the gate was conducted over 1 day on the 4th September and tested that there was no adverse experience with the cassowaries re-entering the gate. Both cassowaries immediately re-entered the gate once the staff had dispersed.

4. Discussion

An integrated strategy is being developed to help mitigate negative impacts of roads and traffic on the endangered southern cassowary in North Queensland. The key elements of this strategy include:

- Road underpasses that mitigate fragmentation and maintain habitat connectivity by providing safe crossing points for cassowaries and other fauna;
- Directional fencing to guide cassowaries and fauna towards these safe crossing points; and
- One-way escape gates with local funnel fencing to provide a means of escape for cassowaries to exit safely if inadvertently trapped within the road corridor.

During the thirty day study, the two captive cassowaries at the Johnstone River Crocodile Park routinely passed through the one-way gate to access their food demonstrating that the design of the gate was both safe and suitable for use by a cassowary.

The strategy of using a shadecloth fence as directional fencing providing a visual cue to the gate and the funnel entrance to the gate, was demonstrated as effective from the start of the trials as the cassowaries immediately lined up to the escape gate as a means of access to their food supply. This is an important and significant observation as the cassowaries were captive in a cyclone mesh compound and the birds had no previous exposure to gates or a shadecloth fence. The birds' behaviour when introduced to the fence and gate differed to their normal behaviour when walking the compound mesh fence. Their normal behaviour with the compound mesh fence was a stereotypical caged pacing behaviour a set distance from the fence occasionally rubbing against the fence. The initial cassowary behaviour to the shadecloth fence and one-way escape gate was different in that the birds immediately differentiated the shadecloth fence to the gate and inquisitively moved towards the gate as the means of moving towards their food. The cassowaries could see the food container and tried the direct route to their food source through the gate. The birds walked up to the gate and moved towards the local funnel entry but stood away from the gate moving from side to side about the opening unsure as to whether they could enter. This behaviour was repeated frequently during the first two days, sometimes only minutes apart. The frequency was increased between dawn and the normal feeding time of 8:00am. Each time the birds would go into the funnel entry and investigate the escape gate from about 0.5 metre and not take the next step into the gate. Only one attempt at entering the gate was observed during the first two days: Henry pushed his neck forward in to the opening and then retreated.

It was particularly important to demonstrate that the one-way gate would operate safely should a cassowary withdraw after initiating entry. Safe withdrawal from the gate was demonstrated on two occasions during this study, resulting in no negative experience. Throughout the risk assessment process undertaken in both the design phase and preparation for the study it was imperative to confirm through a controlled trial situation that the gate was safe to be used by a cassowary.

In the first three days neither bird had passed through the gate. It was decided to alter the vertical gap between each pair of opposing fingers and widen the gap from 100mm to 200mm. Additionally, at the same time as the gap between the ball ends of the fingers was widened, the fourth pair of fingers from the top of the gate were removed. The reasoning was to increase the perceived 'visual window' to encourage usage. Once these modifications were completed, the smaller cassowary (Henry) used the gate within three minutes, however he kept his head well below the pair of removed fingers before, during and after he passed through the gate. The missing fingers were then replaced for the remainder of the trials, and were not considered important for initial entry. Based on this change, 200mm appears to be the appropriate width to encourage entry and was used for the remainder of the trial period

It is hypothesised that the vertical gap may in fact need to be a certain width before cassowaries feel comfortable enough to enter. Cassowaries have an array of numerous facial whiskers on their upper mandible around their eyes known as rictal bristles. Rictal bristles are thought to have a sensory function to determine proximity similar to the vibrissae in many mammals, e.g. cats (Lederer 1972) The measured dimensions of the birds head was 90mm in width with 20mm of whisker extension each side providing an overall width of 130mm, slightly greater than the initial vertical gap of the fingers. This logic appears even more likely when observing the slender vertically compressed profile of the body beneath the feathers.

An essential issue was to ensure that the cassowaries' good health and well being was not compromised as a result of the trials. It was agreed with JRCF staff that should either of the cassowaries not enter the trial area to feed, then on the second day they were to be hand fed a limited amount of fruit each so as to not completely satisfy any hunger. If they passed through the gate, then the birds were to be allowed time to feed followed by release back into the main enclosure to resume the trial.

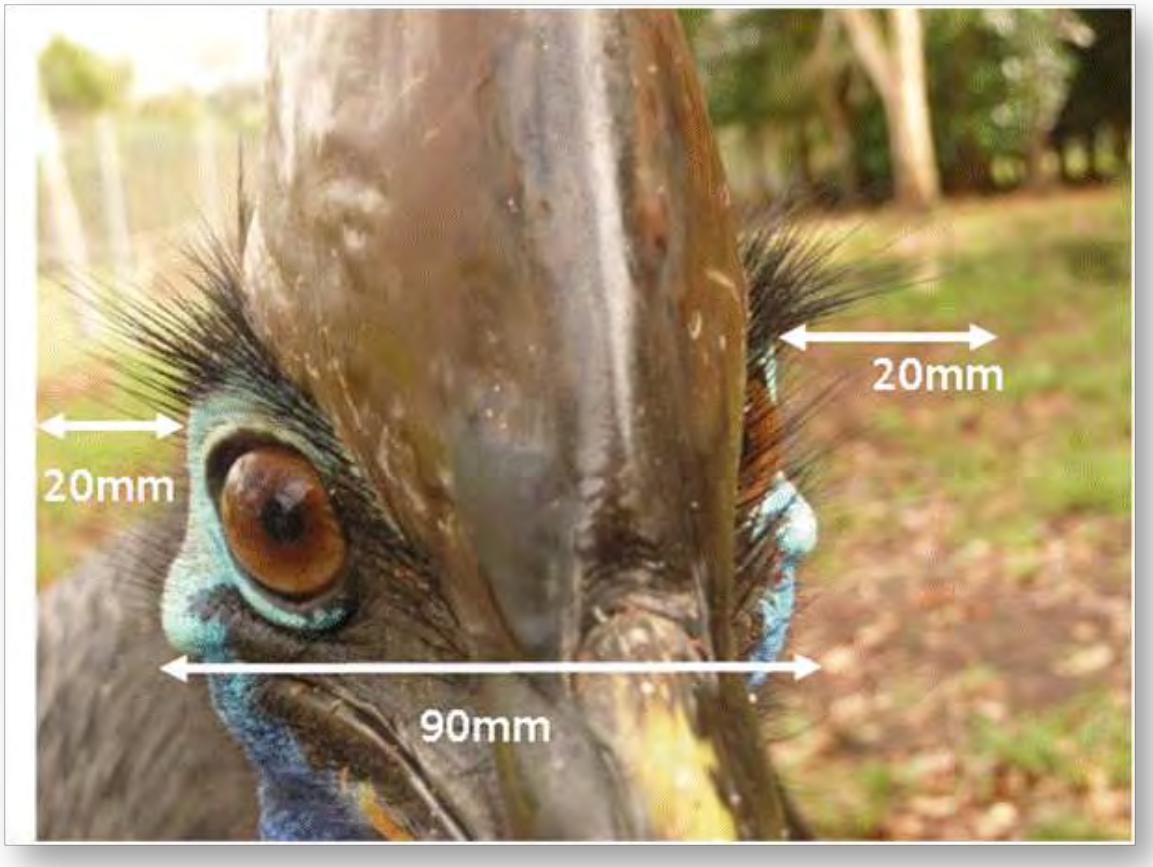

Figure 10: Cassowary rictal bristle dimensions

In Trial 2 it was demonstrated that the birds chose to use the one-way gate even when an alternative entry point was made available. The cassowaries predominantly entered through the escape gate and exited through the open part of the fence. This result established that the cassowaries were not averse to using the gate, and used it as a normal part of their environment. A possible explanation is that access through the one-way gate was the only visual means from the main enclosure, and would have provided the closest point of access to the cassowaries feeding station. However, as the birds exited through the opening in the

fence and often followed the cyclone fencing of their enclosure past the open gate it can only be concluded that the birds did not experience the one-way escape gate as a barrier.

After twenty six days of use, the one-way gate was reversed for Trial 3 to test that the gate worked as a true single directional gate. Neither bird attempted to physically pass through in the wrong direction, despite being accustomed to using the gate in order to access their food. With the gate reversed, the fingers of the gate faced back towards the birds. The birds would approach either side of the gate facing towards the fingers and walk out around the 200mm opening between the fingers to the other side set of fingers. At no time did the birds attempt to enter through the gap between the fingers, but moved past the ball end of the fingers towards the closed barrier of the base of the fingers. The birds seemed a little puzzled that they had previously been able to pass through the gate but this no longer appeared possible. This demonstrated that the gate design was successful in restricting access in the 'wrong' direction.

In Trial 4 the gate was returned to the correct direction for the birds to access their food. Both birds immediately entered through the gate within minutes of the staff dispersing from the area, demonstrating that the previous reversed mode was effective in acting as a one-way gate and the birds had not lost their desire to enter through the gate.

It is recognised that the use of captive cassowaries in this study limits the inference that can be made in relation to the design and suitability of the gate for use by cassowaries in the wild. There are a number of differences between these birds and their habit to birds in the wild. The motivation for the captive cassowaries was provided by their feeding station, whereas wild cassowaries would not have a line of site feeding location. Although this study used the motivation of food, neither Wally nor Henry appeared particularly hungry when allowed to feed after the two days of no food, suggesting that their hunger motivation to enter the gate was not high. On a normal day Wally and Henry are allowed to free feed with fresh fruit available all day. However in the wild, the male cassowary will alone incubate and guard the eggs for up to 50 days (DERM, 2009) without leaving to forage, thus a day or two passing without food should not be a serious concern for a male cassowary.

The cassowary enclosure at the Johnstone River Crocodile Park does not contain any understorey vegetation whereas cassowaries in the wild often move through areas of dense rainforest, regularly negotiating thick stands of vegetation e.g. Lawyer Cane. As a result, Wally and Henry are not accustomed to having to push through such barriers, whereas wild cassowaries are familiar with the sensation of pushing through vegetation and would possibly be less reluctant when presented with the barrier of fingers of the one-way gate.

While the distinctions between captive and wild bird motivation are hypothetical, there is strong indication that cassowaries in the wild are likely to use the one-way gate. Ideally, the space between opposing fingers on the gate should be as small as possible while still encouraging entry. For the same reasons outlined above, cassowaries in the wild may be more inclined to attempt to push through the gate in the wrong direction compared with Wally and Henry, particularly when tempted with a large visual window. The directional fencing and localised funnelling to the gate was successful in focusing the captive cassowaries that the entry was in the visual window of the gate and future work should be focussed on vegetation screening of the fence.

5. Conclusion

This study has successfully demonstrated that the one-way escape gate with directional fencing is safe and is utilised by captive cassowaries when motivated through feeding.

These results have important implications for cassowary conservation. To date, measures to reduce the negative impacts of roads and traffic on the species have not been successful and road strike continues to be the number one cause of adult cassowary deaths (WTMA, 2009) in many areas, particularly Mission Beach (DERM 2009). While the concept of directional road fencing and fauna underpasses as safe crossing points is not new, the Department of Main Roads identified that a major impediment to effective implementation of this strategy was that to date 'no effective escape mechanism' had been developed (Scott 2009). The results of these trials, have made a positive advancement into producing a practical, demonstrated solution to this identified need.

While the results presented here are encouraging for the future use of the one-way gate along roads in north Queensland, additional monitoring and experimental studies will be required to further demonstrate its efficiency. One important finding of this study is that use of the gate by cassowaries appears to be dependent on a suitable gap between each pair of opposing fingers of around 200mm.

Although this result is based on captive cassowary behaviour, which is likely to differ to the behaviour shown by cassowaries in the wild, any inference made from these results therefore needs to be qualified with this distinction. The implications are particularly relevant when trying to resolve detailed design specifications for the gate: too small a space between the opposing fingers and the cassowaries may be reluctant to enter; too large and the cassowaries may attempt to push through the gate in the wrong direction. To help resolve this problem, it would be useful to conduct additional trials to more rigorously test the affect that different width gaps have on wild cassowary use of the one-way gate.

While field trials are relevant, the most conclusive evidence of the function and value of the one-way gate will be obtained through in situ observation. Comprehensive monitoring of cassowary use of the directional fencing, safe underpass crossing points and one-way escape gates will provide the most effective evaluation of the strategy in mitigating impacts from roads and traffic. It will also enable adaptive management to ensure continual improvement of the system.

6. References

Bentrupperbäumer, J.M. (1998). *Reciprocal ecosystem impact and behavioural interactions between cassowaries, Casuarius casuarius, and humans, Homo sapiens, exploring the natural-human environment interface and its implications for endangered species recovery*. Ph.D. Thesis. Townsville: James Cook University of North Queensland.

Buosi, P. & Burnett S. (2006). *The Southern Cassowary (Casuarius casuarius johnsonii): Review of Values and Threats in the Wet Tropics Bioregion, Queensland*. A report for DEH. Queensland: Natural Resources Assessments Environmental Consultants.

Clevenger, A. P., Chruszcz B., and Gunson K. E. (2001). *Highway mitigation fencing reduces wildlife-vehicle collisions.* Wildlife Society Bulletin 29:646-653.

Francis D & O'Malley T (2008), *Wongaling Corridors Fauna Crossings*. A Report to Terrain NRM

Huijser, M.P., McGowen P., Fuller J., Hardy A., Kociolek A., Clevenger A.P., Smith D. & Ament R. (2007). *Wildlife-vehicle collision reduction study.* Report to congress, U.S. Department of Transportation, Federal Highway Administration, Washington D.C., USA.

Knapp, K. K., Oakasa T., Thimm W., Hudson E., and Rathmann C.. (2004). *Deer vehicle crash coutermeasure toolbox: A decision and choice resource.* Wisconsin Department of Transportation, Madison.

Maehr, D.S., Land E.D. & Roelke M.E.. (1991). *Mortality patterns of panthers in southwest Florida*. In: Eversole, A.G. (ed.). Proceedings of the Annual Conference of the Southeastern Fish and Wildlife Agencies: 201-207. Southeastern Fish and Wildlife Agencies, White Sulphur Springs, West Virginia.

Moore, L., (2007) *Ella Bay Cassowary Assessment: Volumes I – III* A report for Ella Bay Development Environmental Impact Study,.

Latch, P. (2007) *National recovery plan for the southern cassowary Casuarius casuarius johnsonii* . Report to Department of the Environment, Water, Heritage and the Arts, Canberra.

Lederer R.J., (1972) *The Role of Avian Rictal Bristles*, The Wilson Bulletin, Vol. 84, No. 2 (Jun., 1972), pp. 193-197.

Puglisi, M.J., Lindzeey. J.S. & Bellis, E.D. (1974) *Factors Associated with Highway Mortality of White_Tailed* Journal of Wildlife Management, Vol 38, 799-807.

Romer, L. (ed)., (1997) *Cassowary Husbandry Manual*, Proceedings of February 1996 Workshop. Currumbin Sanctuary, Currumbin,.

Sielecki L., & Leonard E., (2007) *The Evolution of Wildlife Exclusion System on Highways in British Columbia*. In Proceedings of the International Conference on Ecology and Transportation.

Scott, S., (2009) *Fauna Sensitive Road Design*, Department of Main Roads Presentation to the Wet Tropics Management Authority Cassowary Summit (Sept., 2009 Cairns).