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**Anthelmintic Treatment and Digestive Organ
Morphology of Captive-Reared Kaki
(*Himantopus novaezelandiae*)
Released to the Wild**

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from
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I will conclude my description of the natural history of these islands [the Galapagos], by giving an account of the extreme tameness of the birds.

This disposition is common to all the terrestrial species; namely, to the mocking-thrushes, the finches, wrens, tyrant-flycatchers, the dove, and carrion-buzzard. All of them often approached sufficiently near to be killed with a switch, and sometimes, as I myself tried, with a cap or hat. A gun is here almost superfluous; for with the muzzle I pushed a hawk off the branch of a tree. One day, whilst lying down, a mocking-thrush alighted on the edge of a pitcher, made of the shell of a tortoise, which I held in my hand, and began very quietly to sip the water; it allowed me to lift it from the ground whilst seated on the vessel: I often tried, and very nearly succeeded, in catching these birds by their legs. Formerly the birds appear to have been even tamer than at present. Cowley (in the year 1684) says that the 'Turtle-doves were so tame, that they would often alight upon our hats and arms, so as that we could take them alive: they not fearing man, until such time as some of our company did fire at them, whereby they were rendered more shy.' Dampier also, in the same year, says that a man in a morning's walk might kill six or seven dozen of these doves. At present, although certainly very tame, they do not alight on people's arms, nor do they suffer themselves to be killed in such large numbers. It is surprising that they have not become wilder; for these islands during the last hundred and fifty years have been frequently visited by buccaneers and whalers; and the sailors, wandering through the woods in search of tortoises, always take cruel delight in knocking down the little birds.

These birds, although now still more persecuted, do not readily become wild: in Charles Island, which had then been colonized about six years, I saw a boy sitting by a well with a switch in his hand, with which he killed the doves and finches as they came to drink. He had already procured a little heap of them for his dinner; and he said that he had constantly been in the habit of waiting by this well for the same purpose. It would appear that the birds in this archipelago, not having as yet learnt that man is a more dangerous animal than the tortoise or the *Amblyrhynchus* disregard him, in the same manner as in England shy birds, such as magpies, disregard the cows and horses grazing in our fields.

Source: Excerpt from *Journal of Researches into the Geology and Natural History of the Various Countries Visited by H.M.S. Beagle* by Charles Darwin (London: H. Colburn, 1839).

Abstract

The continued existence of New Zealand's critically endangered and endemic black stilt or kaki (*Himantopus novaezelandiae*) relies on an intensive captive management programme. While this is successful at rearing large numbers of birds for release to the wild, poor survivability of these birds is limiting significant increases in the wild population. Predation and starvation are suspected to be the most common causes of death in released birds, but underlying contributing factors to these mortalities have not been fully evaluated. This research investigates the possible contribution of gastrointestinal (GI) helminth burdens and suboptimal digestive organ development to the high mortality rates of released kaki. Emphasis is placed on evaluating the methods used to assess the importance of these factors and to make informed recommendations for future management.

The efficacy of the anthelmintic regime used for kaki was assessed by dosing half of the 80 captive birds with praziquantel (PZQ) prior to release in 2007. Faecal samples were collected before and after anthelmintic treatment, and before and after release to the wild. *Post mortem* worm counts were conducted on 11 birds that died following release and historical worm count records dating back to 1997 were accessed. The main findings were: PZQ had high efficacy against trematodes; treatment did not prevent re-infection; birds were exposed to helminths at release site; and there was no advantage of treatment for survival. Overall, the results suggest that anthelmintic treatment is an unnecessary cost. Consequently, recommendations were made to cease anthelmintic treatment or reduce its intensity, continue health screening, and incorporate annual efficacy testing to monitor the emergence of anthelmintic resistance.

The reliability of faecal screening for GI helminths was evaluated. Faecal egg counts (FECs) were found to be poor indicators of worm burden. The two modified sedimentation methods used to detect trematodes provided relatively low egg recovery rates. Trematode egg shedding varied between days but not by hour of the day or temperature. The collection and analysis of pooled faecal samples proved to be more cost and time-effective than samples from individual birds and the larger masses collected resulted in greater sensitivity. In conclusion, faecal analysis of pooled samples is a useful qualitative indicator of helminth presence or absence but is quantitatively unreliable.

In order to assess the importance of digestive organ development to captive-reared and released kakī, the digestive organs of healthy and emaciated captive, released and wild *Himantopus* sp. were compared. Captive and released kakī had generally smaller digestive organs than wild birds, released birds did not increase digestive organ size to match the high fibre wild diet, and emaciated birds did not have atrophied organs. However, the greatest mortality rates occur soon after release, while the birds were still being supplementary fed. These results suggest that reduced digestive efficiency is probably not contributing significantly to mortality rates and the direct impacts of the translocation are probably greater risk factors. The continued provision of supplementary food to released birds and an increased focus on habitat enhancement and predator control at release sites were recommended. The reliability of comparing fresh and formalin fixed *Himantopus* sp. gut specimens was evaluated. Significant differences in fresh and formalin fixed organ dry masses and variation in preserved organ lengths indicate that this variation should be considered in future studies.

In conclusion, current management practices appear to be successful in ensuring that GI helminths and reduced digestive efficiency do not significantly lower the survivorship of captive-reared and released kakī. There is a need for further research into developing a more direct physiological assessment of the impacts of GI helminths and gut morphology as well as considering the role that starvation may have on poor survivability.

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My biggest thanks go to my supervisors: Associate Professor Maurice Alley, Dr. Brett Gartrell and Dr. Isabel Castro. Thank you all for believing in me; for making me laugh when things didn't go to plan; for filling my head with lots of weird and wonderful ideas; for increasing my level of enthusiasm whenever it started to wane; and for bringing me back down to earth when I had too many ideas floating around in my head! Thanks also to Nicolas Lopez-Villalobos for being a great statistics advisor.

I would like to thank Emily Sancha, the former kakī aviculturalist, who came up with many of the ideas behind this research. Thank you Em for being so supportive of my research and for being available to help me whenever I needed it (even when you were busy having baby Toby!). I am very grateful for the support and help that Richard Maloney from DOC has given me along the way too.

During the course of my research, I spent 8 weeks in Twizel collecting bird droppings. I would like to thank Twizel DOC for letting me stay at the kakī aviary house during that time. I wouldn't have survived without the company of Jo Hiscock and Emma Stephen who also lived at the house. Thanks to Lana Hastie and Ivan Andrews for their companionship in Twizel also. Thank you Dave Murray and Marcia Fairhall for taking me out to the study sites and for teaching me so much about kakī and the MacKenzie Basin. Mum, thank you for making the trip down to visit me. You were also very good at scrubbing the faecal collection sheets!

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I also acknowledge the financial support that I received from the Association of Avian Veterinarians, the IVABS research and travel funds, the Phyllis Irene Grey Fellowship in Veterinary Science, the Manawatu Branch of the Federation of Graduate Women and the Golden Plover Award (from the NZ Wetland Trust).

As anyone who has written a thesis before will know; it can be quite an eventful / stressful time! I am so grateful for the support I had from my fellow Ecology post-grads during this time. Thanks so much to my amazing flat mate Nicki Atkinson and also to Esta Chappell, Lorraine Cook and Danielle Middleton; in a weird way I will miss all the times we spent complaining about the state of our theses. And last, but not least, Laura Donaldson: Yay, we finally finished!

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List of Abbreviations

ANCOVA	Analysis of Covariance
ANOVA	Analysis of Variance
BIA	Biological Impedance Analysis
DH	Definitive Vertebrate Host
DOC	New Zealand Department of Conservation
EPG	Eggs per Gram
FEC	Faecal Egg Count
FECR	Faecal Egg Count Reduction
FIH	First Intermediate Host
GI	Gastrointestinal
IUCN	International Union for the Conservation of Nature and Natural Resources
IVABS	Institute of Veterinary, Animal and Biomedical Sciences
MANOVA	Multivariate Analysis of Variance
NIWA	National Institute of Water and Atmospheric Research
PRR	Project River Recovery
PZQ	Praziquantel
SAS	Statistical Analysis System
SIH	Second Intermediate Host
TOBEC	Total Body Electrical Conductivity
TWC	Total Worm Count

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Preface

This thesis is formatted as a general introduction, three distinct research papers and a general discussion. Because each research chapter represents an individual paper, there is some repetition between chapters and the general introduction. The format and language (American vs. New Zealand English) of the research chapters also differs depending on the specific requirements of each journal.

All the work presented in this thesis is my own and the multiple authorships that will be ascribed to each research chapter will acknowledge the contributions made by my supervisors and other collaborators.

Approval from the Massey University Animal Ethics Committee was not required for this research as data collected from live birds was carried out in conjunction with normal Department of Conservation release protocols. Kaki are taonga of the Ngāi Tahu tribe and permission was granted by them to utilise specimens from dead kaki.

Both the European and Māori names for the black stilt are used throughout the thesis. For the purposes of publication, the name 'black stilt' is used in the research chapters. For ease of writing, the name 'kaki' is used in the main abstract, general introduction and general discussion.