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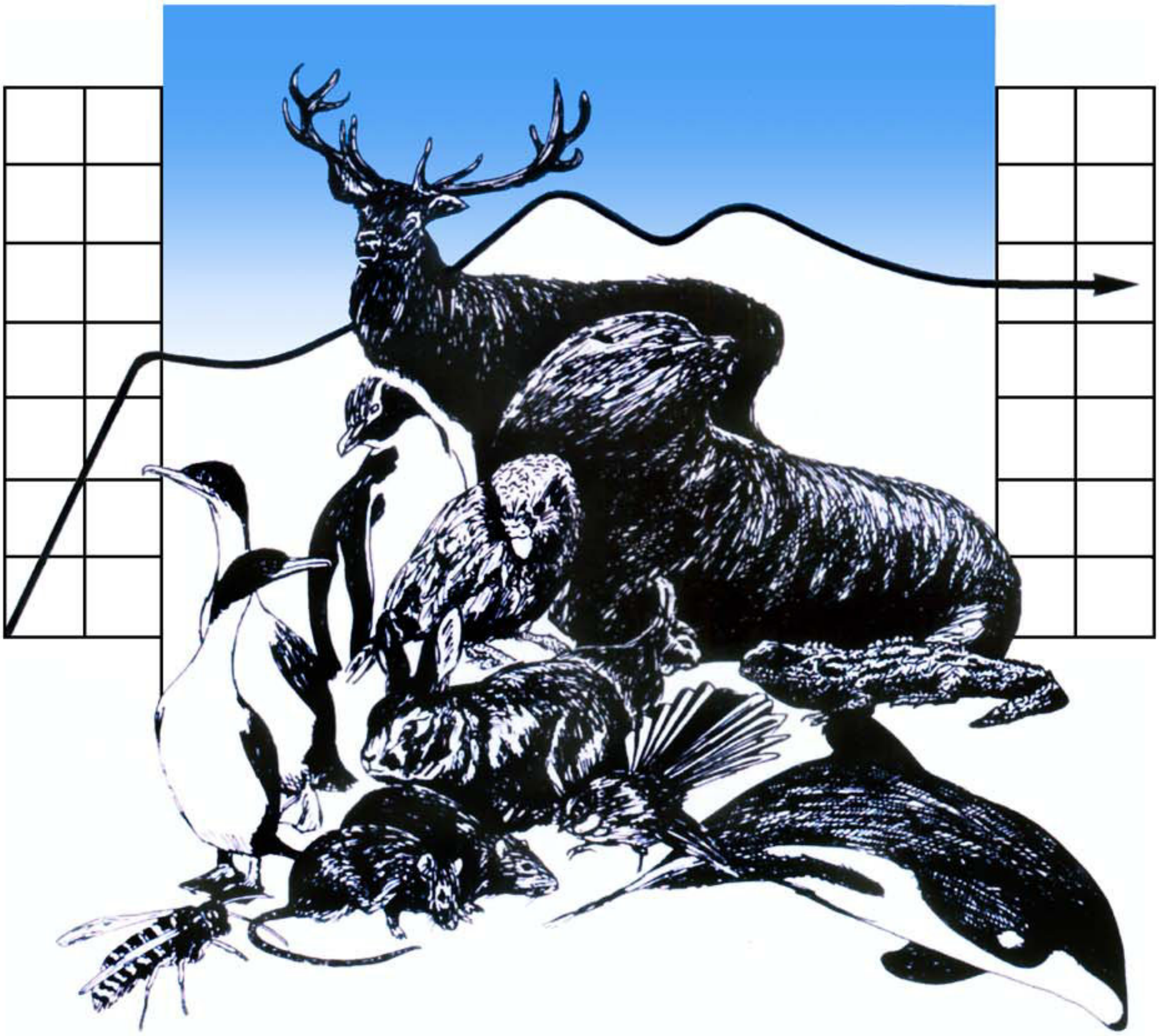

WILDLIFE MANAGEMENT

Pedigree analysis and genetic management of the Kaki

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Executive Summary

Black Stilt or Kaki are endemic to New Zealand and are now restricted to the Waitaki Basin, Canterbury. As one of the world's most endangered birds, intensive conservation of the species by the Department of Conservation (DOC) has been on-going for the last 30 years and has included a captive breeding programme. Although genetic management is recognised as an important factor for the long term fitness of threatened species, it has not been a major part of the Kaki breeding programme.

Using pedigree information from the Kaki programme and a genealogy programme called RootsMagic, I constructed family trees for the two target female Kaki and a number of potential mates. I had three questions for this project. Firstly, which individuals would be the best potential mates for two target female breeding Kaki? Secondly, has the Kaki programme effectively utilised genetic management? Thirdly, does the Kaki programme have a future that would make improved genetic management a realistic goal?

The Kaki aviculturist, Liz Brown and I used the completed Kaki family tree records to choose potential mates for breeding with the target females. While the family trees gave a useful visual guide they did not allow for calculations of relatedness necessary for best-practice genetic management.

Most captive breeding programmes utilize specific studbook and genetic management software to guide captive breeding decisions. Although the Kaki programme has detailed pedigree records for many individuals, the potential benefit of this information for guiding genetic management and therefore improving long-term genetic viability has been neglected.

The Kaki programme has had significant resources allocated to it however the species remains reliant on intensive management and breeding supplementation. Under the new Project Prioritisation Protocol, the Kaki programme may lose its DOC funding thereby ending the captive breeding programme. This could mean that the issue of genetic management for Kaki is not relevant. The species may either become genetically extinct or hybridize with the Poaka.

Kaki are an endemic New Zealand bird whose future depends on a number of factors. Regardless of what the future holds for the Kaki programme, those working for the kaki have thus far ensured the survival of a distinct New Zealand species.

Abstract

The Black Stilt or Kaki (Himantopus novaezelandiae) is one of the world's most endangered birds (Millar et al. 1997, Reed & Murray 1998, Brumfield 2010, Hagen et al. 2011). The Department of Conservation, (DOC), began a captive breeding programme for Kaki in 1986 in Twizel, New Zealand. Genetic management is widely used in threatened species programmes to ensure long-term population viability (Ballou & Lacy 1995, Laikre et al. 1997, Jamieson et al. 2006, Grueber & Jamieson 2008, Hagen et al. 2011, Olano-Marin et al. 2011, Ransler et al. 2011). Although genetic management is mentioned in the Kaki management plan of 1993, there has effectively been little emphasis on genetic management within the captive breeding programme (Liz Brown pers. Comms.).

Using pedigree records inputted into the genealogy programme RootsMagic, I constructed family trees for two target females and a number of juvenile and sub-adult kaki. The family trees were then used to aid management decisions about potential mating pairs. The Kaki programme has not utilized genetic management techniques despite having detailed pedigree records for many birds. More detailed analysis of the birds' pedigrees should be done to guide management within the captive breeding programme. However, due to funding limitations within New Zealand, the issue of best-practice genetic management may be moot, as the budget for Kaki may soon be re-directed to other threatened species (R. Maloney Pers Comms).

Introduction

Kaki and conservation

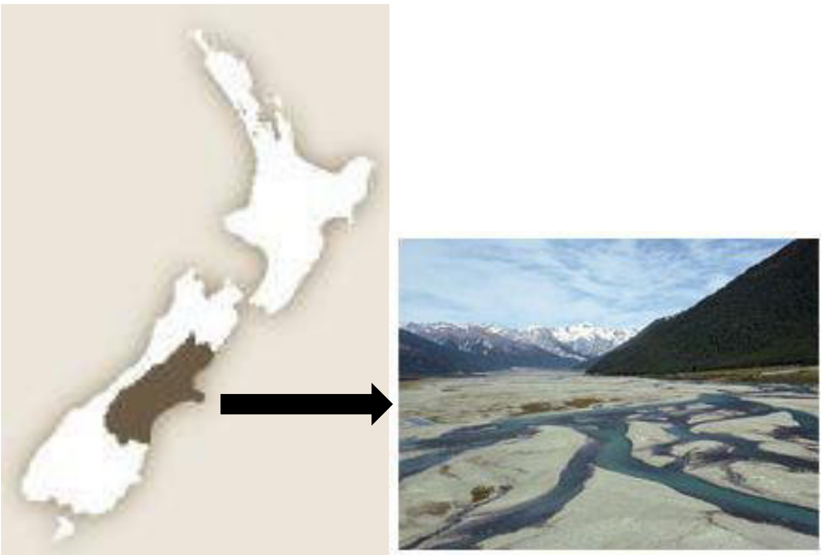
The Black Stilt or Kaki (Himantopus novaezelandiae) is one of the world's most endangered birds (Millar et al. 1997, Reed & Murray 1993, Brumfield 2010, Hagen et al. 2011). Kaki are sexually monomorphic (Millar et al 1997): up to 9 months, juveniles have a mottled plumage which develops to pure black by adulthood at 2 years (van Heezik et al 2005). **Figure 1**. Endemic to New Zealand, this braided river-specialist (Steeves et al 2010, Hagen et al 2011) has undergone a severe population decline reaching a population low of just 28 individuals in 1980 (Reed & Murray 1993, Hagen et al. 2011). Although Kaki were once found across the North and South Islands of New Zealand (Reed & Murray 1993), the current population of 112 wild birds (as of February 28th, 2011 Kaki Fact Sheet, 2011) is now restricted to a

$7500km^2$ area of the Waitaki Basin in South Canterbury (van Heezik et al 2009). **Figure 2**. The decline in kaki numbers is thought to be primarily due to; introduced mammalian predators, habitat loss and hybridization with the self-introduced pied stilt, Himantopus himantopus leucocephalus (Reed & Murray 1993, Steeves et al. 2010, Hagen et al 2011) and has necessitated intensive conservation management to ensure the species' survival (Reed & Murray 1993).

Fig 1. Juvenile and adult Kaki

Images from DOC website and Google images. Accessed February, 2012

Fig 2. Map of New Zealand, (shaded area is the Mackenzie Basin), and the braided river system inhabited by Kaki.



Department of Conservation Website. Accessed Feb, 2012

The Department of Conservation, (DOC), began a captive breeding programme for Kaki in 1986 in Twizel, New Zealand. The two main aims of the Kaki breeding programme were; in the short-term, halt the threat of extinction and in the long-term, have at least one self-sustaining population (Reed, 1998). Since 1997, all Kaki eggs have been reared artificially for release as juveniles or sub-adults (van Heezik et al. 2005). Since 1993, 464 sub-adult and juvenile Kaki have been release into the wild (van Heezik et al. 2009), however despite this supplementation, breeding success in the wild remains low (van Heezik et al. 2009) as does recruitment (Hagen et al. 2011). Kaki numbers have risen but the goal of a self-sustaining wild population is unlikely without continued captive breeding augmentation (Seddon, 2008). Unfortunately for the Kaki, the economic realities of conservation in New Zealand make continued, optimal management increasingly unlikely (R. Maloney Pers. Comms.).

Captive breeding and management

Captive breeding is a key component in many threatened species management programmes (Morrison et al. 2011, Ransler et al. 2011, Smith et al. 2011). Worldwide 168 bird species are captive bred for the purposes of re-introduction and population supplementation (Smith et al. 2011). For many threatened species the pattern is similar, a once abundant species becomes decimated by predation, habitat loss and other anthropogenic factors (For examples: the Whooping crane Jones et al. 2002, the pink pigeon Swinnerton et al. 2004, the grey partridge Parish & Sotherton 2007, the Puerto Rican Parrot Bessinger et al. 2008, the Gyps vulture Khan & Murn 2011, the island scrub jay Morrison et al. 2011, the Trumpeter swan, Ransler et al. 2011). The priority in threatened species conservation is to prevent species extinction (Swinnerton et al. 2004) and then to begin managing the population(s) towards growth and self-sustainability (Millar et al. 1997, Reed 1998).

Maintenance of genetic viability is widely considered a key factor for long-term viability of populations (Ballou & Lacy 1995, Laikre et al. 1997, Jamieson et al. 2006, Grueber & Jamieson 2008, Hagen et al. 2011, Olano-Marin et al. 2011, Ransler et al. 2011), particularly when populations have undergone severe bottlenecks (Briskie & Mackintosh 2004, Briskie 2006). Population bottlenecks increase inbreeding and can lead to decreased heterozygosity, increased genetic load and increased expression of deleterious alleles (Briksie & Mackintosh 2004). If the effects of inbreeding are severe they can affect the long-term viability of small populations by decreasing fitness (Jamieson et al. 2006, O Grady et al. 2006, Herber & Briskie 2009, Jamieson 2009, Szulkin et al. 2009, Laws et al. 2010, Hagen et al. 2011). Inbreeding avoidance in captive management programmes is therefore necessary to maintain genetic variation for long-term population viability (Ballou & Lacy 1995, Baumang & Saulkner 2003, Grueber & Jamieson 2008, Ivy et al. 2009, Meuwissen 2009).

Many captive breeding programmes use studbooks, such as SPARKS (isis@isis.org) to record pedigree information (Jones et al. 2002, Ralls & Ballou 2003, Grueber & Jamieson 2008, Pelletier et al. 2009). This software, in conjunction with other programmes like PM2000 (www.vortex9.org/PMx/PMx.html), can then be used to analyse genetic relationships between individuals for the purpose of inbreeding avoidance (Ballou & Lacy 1995, Grueber & Jamieson 2008, Jamieson 2010). Accurate pedigree information is widely recognised the most important tool for estimating inbreeding (Jones et al. 2002, Ralls & Ballou 2003, Grueber & Jamieson 2008, Pelletier et al. 2009, Grueber et al. 2011, Hagen et al. 2011). However, the increasing availability of genetic technology (Ransler et al. 2011) means that microsatellites DNA markers are often used to estimate relatedness (Grueber et al. 2011, Hagen et al. 2011, Olano-Marin et al. 2011, Wang 2011). A combination of the pedigree and microsatellite information may in fact be the optimal method for measuring genetic relationships especially when pedigree information is incomplete or shallow (Grueber et al. 2011).

Genetic management of the Kaki

Conservation programmes in New Zealand have been slow to realise the importance of population bottlenecks and inbreeding on survival (Jamieson et al. 2006). This may be because as populations decline, the immediate concern is to save the species in the short term; in New Zealand this often means focussing on pest control (Jamieson 2009). Effects of inbreeding depression are often on a long time-scale (Jamieson et al. 2006, Jamieson 2009) and can be difficult to assess, given that ecological systems are complex and that decreased fitness can be a result of both intrinsic and extrinsic factors (O Grady et al. 2006, Laws et al. 2010). Although genetic management is mentioned in the Kaki management plan of 1993, there has effectively been little emphasis on genetic management (Liz Brown pers. Comms.). In recent years there has been some research into genetic analysis of Kaki through microsatellite DNA markers (Steeves et al. 2008, Steeves 2010, Hagen et al. 2011) however there appears to be a disconnect between the research and theory of Kaki genetics and their practical application (Liz Brown Pers. Comms.). The kaki aviculturist (Liz Brown) makes decisions about Kaki breeding without the benefit of detailed pedigree or genetic relatedness estimations. Interestingly, the Kaki programme has access to SPARKS studbook programme but does not utilize the software (Liz Brown Pers. Comms.). This could be due to financial and personnel restraints. Like many conservation programmes, the Kaki programme has a limited budget.

The kaki as part of DOC's future

DOC is the primary agency responsible for government funded threatened species work in New Zealand. As with all governmental departments DOC faces funding challenges (Seabrook-Davidson 2010). A new system to help allocate limited conservation spending is set to be used in New Zealand called Project Prioritisation Protocol (PPP). PPP is a system that measures various factors to rank which conservation programmes should be funded and to what degree (Richard Maloney Pers. Comms., Joseph et al. 2008). Although the Kaki programmed has thus far been funded by DOC to a considerable level, there is a strong likelihood that Kaki will lose out under PPP (Richard Maloney Pers. Comms.). Although this could be disastrous for the long-term future of the Kaki population, given that they are still dependent on population supplementation (Seddon 2008), it would free up resources for other threatened species work. Given that a large proportion of the Kaki budget could be withdrawn in the near future, it seems unlikely that increased genetic management within the Kaki breeding programme is a realistic goal.

Project aims

I spent a month living and working on a placement at the Twizel Kaki aviaries. I was given access to Kaki pedigree records in the form of detailed excel spread-sheets and manually drawn family trees. The initial requirement was to fulfil a data-entry role, inputting all Kaki information into an easily accessed computer programme. However, given the time-frame of one month and the huge amount of data, this was not possible. Instead, we decided to try to input relevant individual Kaki data into a family-tree/pedigree software programme.

Initially I had one question: based on family tree information, which individuals would be the best choice for mating with two target females? This question led on to two others: has the Kaki captive management programme utilized effective genetic management? And is there a need for more intensive management of Kaki given the realities and limitations of the programme?

Methods

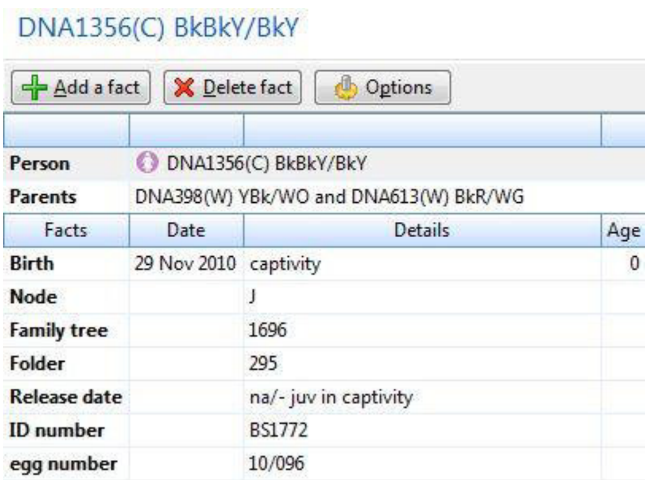
Kaki records

Kaki pedigree information from the captive breeding programme is recorded in an alpha list which contains detailed information about each individual, (such as banding combinations, parentage and hatching date). Over the 31 years of captive breeding at the Twizel facility, the alpha list had become a cumbersome document to work from. The kaki aviculturist wanted information from the alpha list entered into a simple, pedigree programme that would make data easy to access. Although there are a number of studbook programmes available, the available budget would not cover purchase of these programmes. The decision was made to use a family-tree based software, (designed for human lineage analysis), for the Kaki.

Pedigree Software

RootsMagic Version 4.1.1.4 (www.RootsMagic.com) was selected. This software allows entry of individual data into "person" records that can then be used to construct family trees. **Figure 3.** Banding combinations were used as names. In consultation with the aviculturist It was decided that for each individual their "person" record should contain; birth date, node (with J being pure Kaki), DNA identifier where applicable, the corresponding family tree number, (from hand-drawn family tree hard-copies), the release date where applicable, the birds individual ID number, the egg number assigned at birth, the sex and whether the individual was captive or wild.

Fig 3. Person Record as seen in RootsMagic


DNA1356(C) BkBkY/BkY

Add a fact | Delete fact | Options

Person	DNA1356(C) BkBkY/BkY		
Parents	DNA398(W) YBk/WO and DNA613(W) BkR/WG		
Facts	Date	Details	Age
Birth	29 Nov 2010	captivity	0
Node		J	
Family tree		1696	
Folder		295	
Release date		na/- juv in captivity	
ID number		BS1772	
egg number		10/096	

Family Trees
Family tree records were constructed for the following groups, (n = the number of individuals in each category). "Person" records for every individual in each lineage were entered into RootsMagic.

Adult Males (n = 9)
Adults, Unknown Sex (n = 5)
Captive Pairs (n = 8)
Juveniles in Aviary (n = 16)
Other Juveniles in Captivity (n = 6)
Sub-adults (n = 25)
View Birds (n = 2)
Target Females (n = 2)

Pedigree Analysis
There is no function in RootsMagic for calculating relatedness coefficients. However the software does allow you to print family tree charts and reports that illustrate an individual's pedigree. These charts were printed and used to visually assess relatedness between individual birds (see **Appenix 1** for examples). Potential breeders from the list of juveniles and sub-adults were identified for two captive female birds, **GBK/WR** and **BkBkO/BkO**.

Results

Mates for BkBkO
Although female **BkBkO/BkO** was sexually mature, the potential mates for her from within the aviary were not. Therefore, female **BkBkO/BkO** was to be put into an aviary on her own until the potential mates reached sexual maturity, (in 2012). Potential mates from the available juveniles in captivity are shown in **Fig 3**.

Figure 3. Juveniles selected to be potential mates

Aviary	Band Combo.	
C1	BkBkY/WBk	Siblings
	BkBkY/WG	
C10	BkBkY/BkR	
A2	BkBkW/WR	Siblings
	BkBkY/BkW	
C9	BkBkY/OY	

Space in the aviaries is limited so other possible mating combinations along with those for the target female **BkBkO/BkO** had to be considered. As such it was decided that the configuration of the aviaries would be as shown in **Fig 4**.

Figure 4. Combination of birds in the aviaries

Box 1. **Female BkBkO/BkO**	Box 2. **BkBkY/OY** **BkBkY/BkR**
Box 3. **BkBkW/WR** **BkBkY/BkW**	Box 4. **BkBkY/WBk** **BkBkY/WG**

siblings

The plan is that the two birds shown in box 2 Fig. 4 will mate once they reach sexual maturity, although this has not been tried before and there is the fear that instead they will learn to live as siblings not mates. Bird **BkBkY/OY**, (sibling to the two shown in box 3 Fig. 4) had to be held back as a potential captive breeder because it had a crooked beak and birds with this deformity do not often survive in the wild (Liz Brown Pers. Comms.). Once the juveniles in boxes 3 and 4 of Fig. 4 reached sexual maturity, they would be flock-mated with the target female and then with one each other. The male quarantine bird would not be a possible mate for female **BkBkO/BkO** as the two are full siblings.

Mates for GBk/WR
For the second target female, **GBk/WR**, it was decided that the male bird, **BkBkO/BkG**, being held in quarantine in the Twizel facility, would be a possibility, despite the fact that these two birds are first cousins. If the two birds did not mate, then the juveniles being held back as potentials for the female (**BkBkO/BkO)** could be potential mates for **GBk/WR** as well.

Discussion

Analysis errors
There is a large degree of un-certainty in all the results given that Kaki cannot be forced to mate (van Heezik et al. 2009, Hagen et al. 2011) and that the sex of the juveniles and sub-adults was not yet known. Kaki flock-mate and form strong pair bonds (Hagen et al. 2011) and they are also known to form same sex bonds (L. Brown Pers. Comms.). Therefore, it could eventuate that all birds are female, that none of the birds mate at all or that they form same-sex pairs. Furthermore, the decisions made about which juveniles to hold back were based on cursory examinations of family trees and are therefore subject to error. The aviculturist was facing time-constraints due to work commitments outside New Zealand and my placement period was only four weeks. With this limited time-frame, more detailed analysis was not possible.

Although utilizing pedigree information, even in the most cursory way is probably better than blind guesses, the most value for captive breeding decisions would come from in-depth pedigree analysis using appropriate software. Such software can then be used to calculate measures of relatedness such as Wright's inbreeding co-efficient (F): the probability that two alleles in an individual at a given locus are identical by descent or Mean Kinship (MK): the average relatedness of an individual to the population as a whole. Such measures can be used to guide breeding within captive populations to help ensure long-term population viability.

Benefits and limitations of genetic management
The purpose of population genetic management is to make decisions that that will preserve genetic diversity (Ballou & Lacy 1995, Ralls & Ballou 2003). Californian Condors suffered a major population decline necessitating captive management beginning in the late 1980's (Ralls & Ballou 2003). From the start the Condor programme used genetic management

techniques which included the use of SPARKS and PM2000 software (Ballou & lacy 1995). One calculation used in the Condor programme was Mean Kinship (MK) values which were helped identify genetically important individuals (Ralls & Ballou 2003). MK measures the average relatedness of an individual to the population as a whole, therefore, if an individual has many living, close relatives, it's alleles are going to be more common than an individual with fewer living close relatives. Simply put, if an animal has a low MK it is more genetically important. Ralls and Ballou (2003) suggest that strategies using MK will retain the highest levels of genetic and allelic diversity (in model populations). MK can also be calculated where the pedigree contains unknown animals (Ralls & Ballou 2003), as is often the case in wild populations. Ivy et al. (2009) state that the value of MK is limited if parts of the pedigree are incomplete, however there are programmes and models to simulate this information along with the use of molecular techniques to fill in the gaps (Huff et al. 2011).

The Takahe programme is another example of a wild breeding programme that has successfully used pedigree information to guide management choices (Grueber & Jamieson 2008). 18 years of pedigree information from Takahe was analysed using SPARKS and PM2000. Two of the measures used were Mean Kinship (MK) and Gene Diversity (GD) (Grueber & Jamieson 2008). Analysis showed that inbreeding was common amongst Takahe, at 43% and that GD of 90% (a standard recommendation for managed populations) would only be maintained over 12 years, unless appropriate management decisions were executed, (in this case the carrying capacity of the Takahe island population had been reached and another population would need to be started to ensure adequate genetic viability) (Grueber & Jamieson 2008). Using the pedigree analysis, Grueber & Jamieson (2008) were able to guide management decisions in a practical way.

It is not always possible to maintain accurate pedigrees, particularly for wild populations (Grueber et al. 2011) so microsatellite markers can be used to fill in the gaps if necessary (Grueber et al. 2011, Wang 2011). In a recent paper, Hagen et al. (2011) used multilocus microsatellite genotypes as a surrogate for pedigree data to assess the relationship between kaki inbreeding and reproductive success. Heterozygosity fitness correlates (HFC's) are often used to explore the relationship between gene diversity and fitness (Grueber et al. 2011, Olano-Marin et al. 2011) For birds, hatching failure is an often used fitness correlate because it is easily measured and has been shown to increase with the degree of inbreeding (Briskie 2006, Jamieson et al. 2006, Herber & Briskie 2009). Using genotypes at eight microsatellite loci Hagen et al. (2011) found a significant negative relationship between relatedness and reproductive success in captive breeding Kaki from 1998 – 2009. However, as Hagen et al. (2011) themselves state they used a low number of marker loci for their study. Other studies suggest that a far greater number of loci must be used to be effective (Jones et al. 2002, Baumang & Solkner 2003, Grueber & Jamieson 2008, Ivy et al. 2009, Grueber et al. 2011, Olano-Marin et al. 2011). Olano-Marin et al (2011) suggest that using fewer than 10 loci is too low while Baumang & Solkner (2003) recommend that you may need as many as 200 marker loci for information comparably accurate to pedigree depths of 5+ generations.

At the simplest level, genetic management aims to decrease inbreeding in the hopes of; increasing heterozygosity (Meuwissen 2009), increasing fitness (Jamieson 2009), and decreasing the expression of deleterious alleles (Olano-Marin et al. 2011). And while fitness can be measured using HFC's like hatching success and egg fertility (Jamieson 2009), factors along with genetics can play a role (Haig &Ballou 1995, Laws et al. 2010). It can be difficult to separate out the different factors that contribute to a species fitness as these can be both intrinsic (genetic) or extrinsic (environmental) (O Grady et al. 2006). This problem is exacerbated when using molecular techniques, because the relationship between HFC's and multi-locus heterozygosity (MLH) is often weak and may not accurately reflect inbreeding depression (Grueber et al. 2011). Therefore accurate pedigree records may be the best option.

Kaki project recommendations

Many threatened species captive management programmes use pedigree and genetic analysis to guide management decisions (Jones et al. 2002, Grueber & Jameison 2008, Ivy et al. 2009, Pelletier et al. 2009). Although there is increased awareness of the value of genetic management of threatened species (Grueber 2011), it should be noted that it is not the only management technique needed in most cases (Jamieson 2009). In New Zealand, one of the main agents of decline for many endemic species is introduced pests (Jamieson et al. 2006). Therefore it is crucial that intensive pest control continues for the Kaki and in other threatened species programmes. However, because inbreeding depression could have serious negative consequences for the Kaki (Briskie & Mackintosh 2004, O Grady et al. 2006, Suwanlee et al. 2007, Hagen et al. 2011), management should consider the effects of inbreeding on potential long-term kaki population success.

The Kaki programme has detailed pedigrees for many individuals. As all Kaki are captive reared, in time there should be deep enough pedigrees to be of value to management decisions (Hagen et al. 2011). Even with gaps or errors in the pedigree, pedigree analysis can identify inbred animals more accurately than using limited numbers of polymorphic loci

(Baumang & Solkner 2003). However, before the pedigree information can be of any practical use in captive breeding decisions it must be maintained in an appropriate software package. Given that other threatened species programmes such as the Condor and Takahe programmes have used SPARKS and PM2000, these software packages could also be used to guide genetic management for the Kaki.

Do Kaki have a long-term?

Global biodiversity is diminishing rapidly (Butchart et al. 2006) and funding for conservation is limited (Marris 2007, Pearce 2007, Wilson et al. 2011) therefore pragmatism in conservation is needed (Robinson 2011). Conservation programmes that are funded primarily through governmental budgets have to take into account a broader perspective (Purdy & Decker 1989, Ludwig et al. 2001, Seabrook-Davidson 2010, Minteer & Miller 2011). This may mean that funding for some conservation programmes is not available or not considered important enough in the broader economic paradigm. While it is distasteful to think about letting a species go extinct through inaction, this bigger context needs to be considered (Robinson 2011). The kaki programmed is funded through DOC, a governmental department with a limited budget (Seabrook-Davidson 2010). Decisions about continued funding for the Kaki cannot therefore be viewed from a single-species conservation perspective only.

New Zealand's conservation estate is facing serious funding challenges (Marris 2007, Joseph et al. 2007, Joseph et al. 2008). In a survey of DOC staff, Seabrook-Davidson (2010) found that DOC has inadequate resources, inadequate staff and too much to do. A new system for allocating conservation resources in New Zealand, called Project Prioritization Protocol (PPP), is being used to direct funding for threatened species (R. Maloney Pers. Comms.). The aim of PPP is to make decisions about funding allocation in a transparent and cost-effective manner (Joseph et al. 2008, R Maloney Pers. Comms). PPP is distinct from other conservation rating systems because it includes measures for cost and for the likelihood of success of a project (Joseph et al. 2007). Under the PPP rankings, Kaki will not make the cut for DOC threatened species funding (R. Maloney Pers. Comms.). Given that Kaki have been intensively managed for over 30 years yet they are still dependent on continued supplementation from captive breeding (Seddon 2008), will the species survive if their budget does not? Furthermore, does it really matter? Pearce (2007) suggests that; *"There is no* pleasure in reporting the suspicion that, despite all the rhetoric, the world does not care too much ab*out biodiversity conservation"* With this in mind, discussions about the value of genetic management of the Kaki may just be semantics.

Since 2000 management practices for Kaki have actively prevented hybridization between Kaki and the self-introduced Pied Stilt or Poaka (Steeves 2010). However, hybridization is widespread in birds (Grant & Grant 1992) and in some cases can increase fitness (Grant & Grant 1992). Hybridization can also be an important component in a species evolutionary trajectory (Genovart 2009) Poaka are self-introduced and have been breeding with kaki for the last 50 years (Steeves et al. 2010). Interactions between Poaka and Kaki have been influenced by anthropogenic factors (Steeves et al. 2010) however, hybridization between the two species occurs naturally in the wild. Furthermore hybrid offspring are fertile (Steeves et al 2010) so continued hybridization could be seen as a means of genetic rescue for the species by reducing the genetic load (Steeves et al. 2010). Steeves et al. (2010) suggest that there is little evidence of inbreeding in the Kaki based on microsatellite data. However, the small number of microsatellite markers used in their study may affect the voracity of that argument (Jones et al. 2002, Baumang & Solkner 2003, Grueber & Jamieson 2008, Ivy et al. 2009, Grueber et al. 2011, Olano-Marin et al. 2011). Thorough analysis of Kaki pedigrees could reveal higher levels of inbreeding than Steeves et al (2010) suggest thus necessitating genetic rescue through hybridization. Furthermore Kaki may not be one of the more instantly recognizable and charismatic bird species in New Zealand. Conservation work in DOC is directed by governmental policy which should, at least in theory reflect societal wishes. Would it really matter to the majority of New Zealanders if Kaki started to look slightly more like Poaka? Would very many people actually even know the difference?

Conclusions

1. Family trees for the Kaki provided a simple visual guide for choosing potential mates for the two target female Kaki. However more complex pedigree analysis is needed for the future.

2. Kaki pedigree information has been under-valued by management. Studbooks should have been used from the start of the Kaki project so that genetic management based on pedigrees could be done at a practical level. Furthermore, the genetic work, (based on micro-satellite markers), that is being done at the moment needs to be integrated into the practical side of the Kaki programme rather than having a disconnect between genetic theory and day to day practice. Genetic management has come to the forefront in many captive management schemes. A combination of pedigree information and DNA information should be used to inform management decisions with the aim of increasing genetic diversity, leading to viable, long-term population(s) survival.

3. Kaki numbers have increased with management but they are still not self-sustainable. If the budget for the Kaki programme is lost under PPP, this will free up money for other threatened species. And while the Kaki, as they are now, may not survive, they have the potential to hybridize naturally in the wild with Poaka.

Closing thoughts and acknowledgements

The DOC staff who work with Kaki are dedicated and do amazing work with the species. I do not mean to disparage or undermine their efforts in any way through my suppositions. I thoroughly enjoyed working with the Kaki during my placement and grew very fond of the birds. In an ideal world, I would like funding and management of the Kaki to continue and to include best-practice genetic management techniques. However, I am a pragmatist. There are a lot of wonderful species that are currently threatened. If I had to choose between the "value" of Kaki and other species, I am afraid the Kaki would lose out. Like proponents of PPP I think limited funding should be directed at those projects that have a chance of success (among other considerations). Whatever happens, I was very privileged to get to know the Kaki and the people who work so tirelessly for them. I would like to express my gratitude to the whole Kaki team especially Liz, Ivan and Mike, who along with helping me, made the placement great fun.

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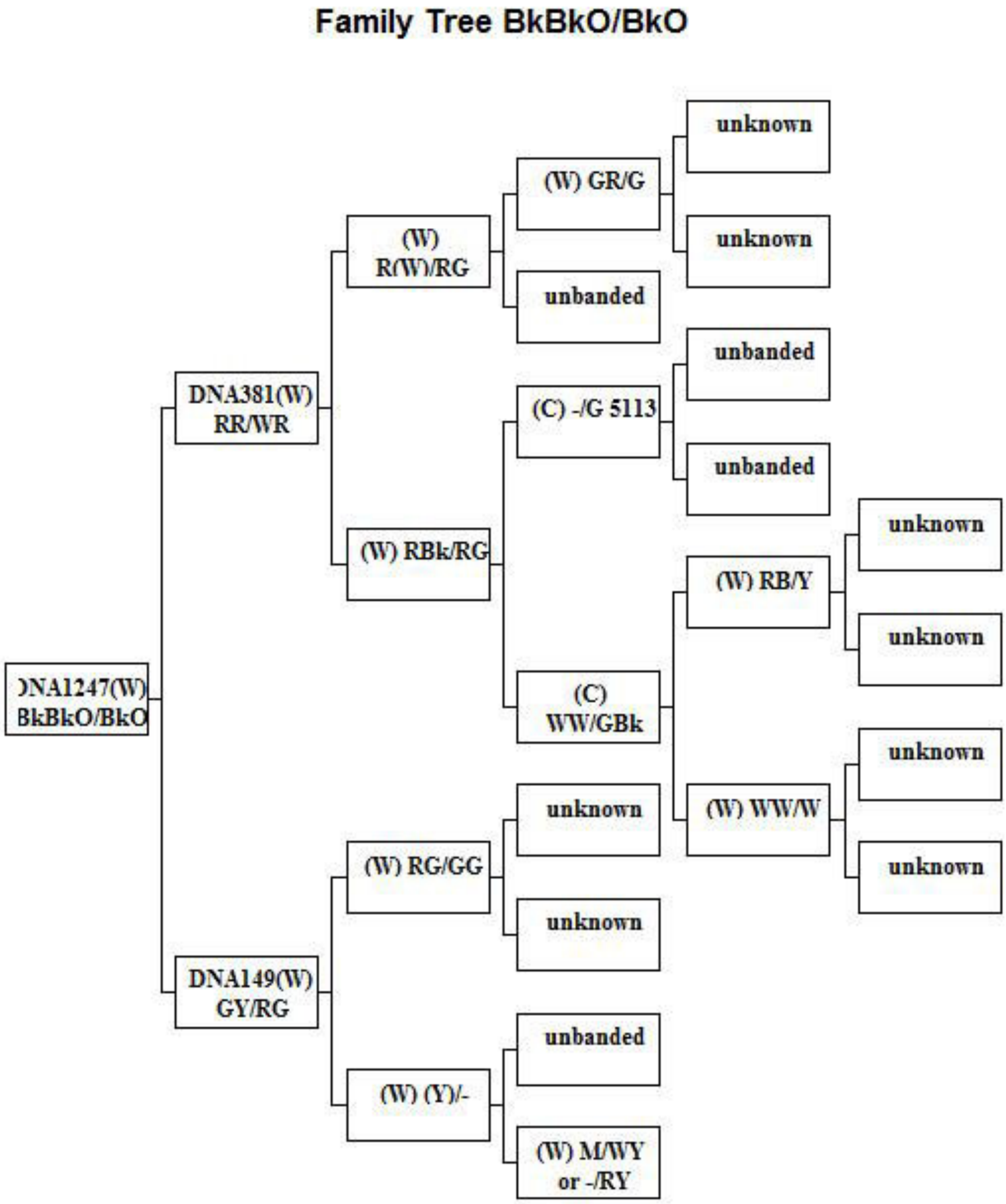
Appendix 1.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(W) RG/GG
(W) (Y)/-
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unbanded
(C) -/G 5113
(C) WW/GBk
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unknown
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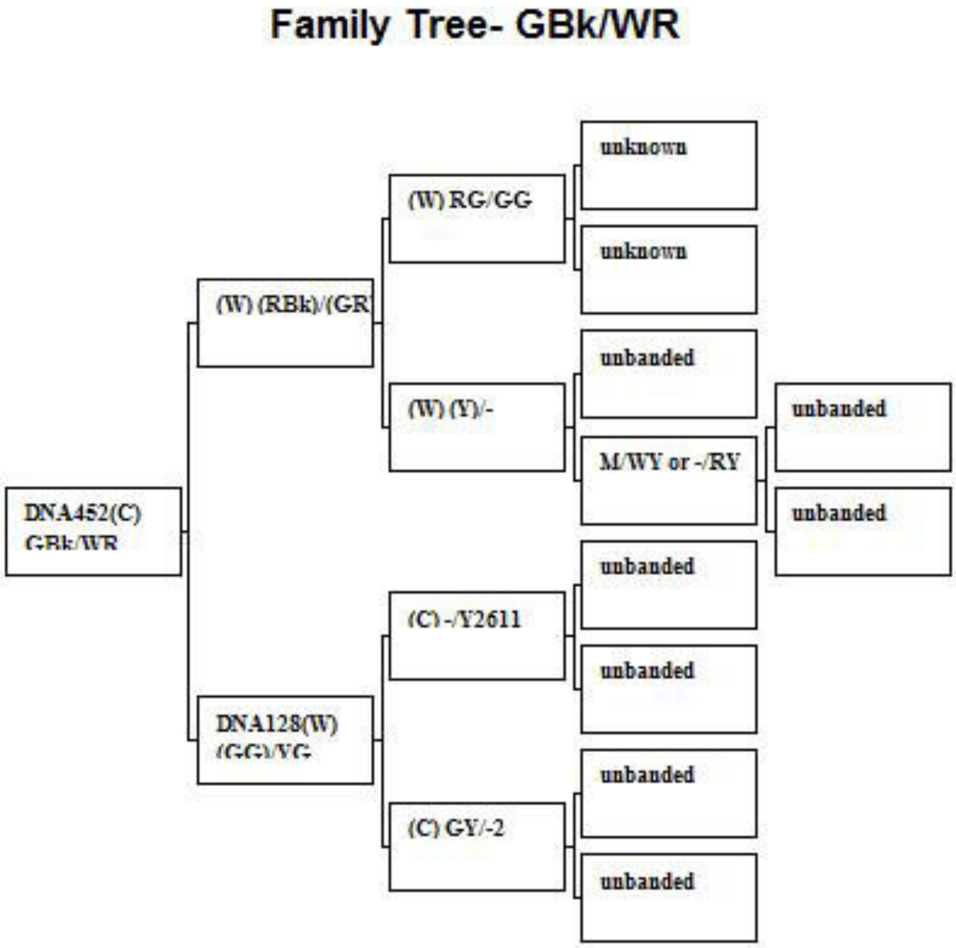
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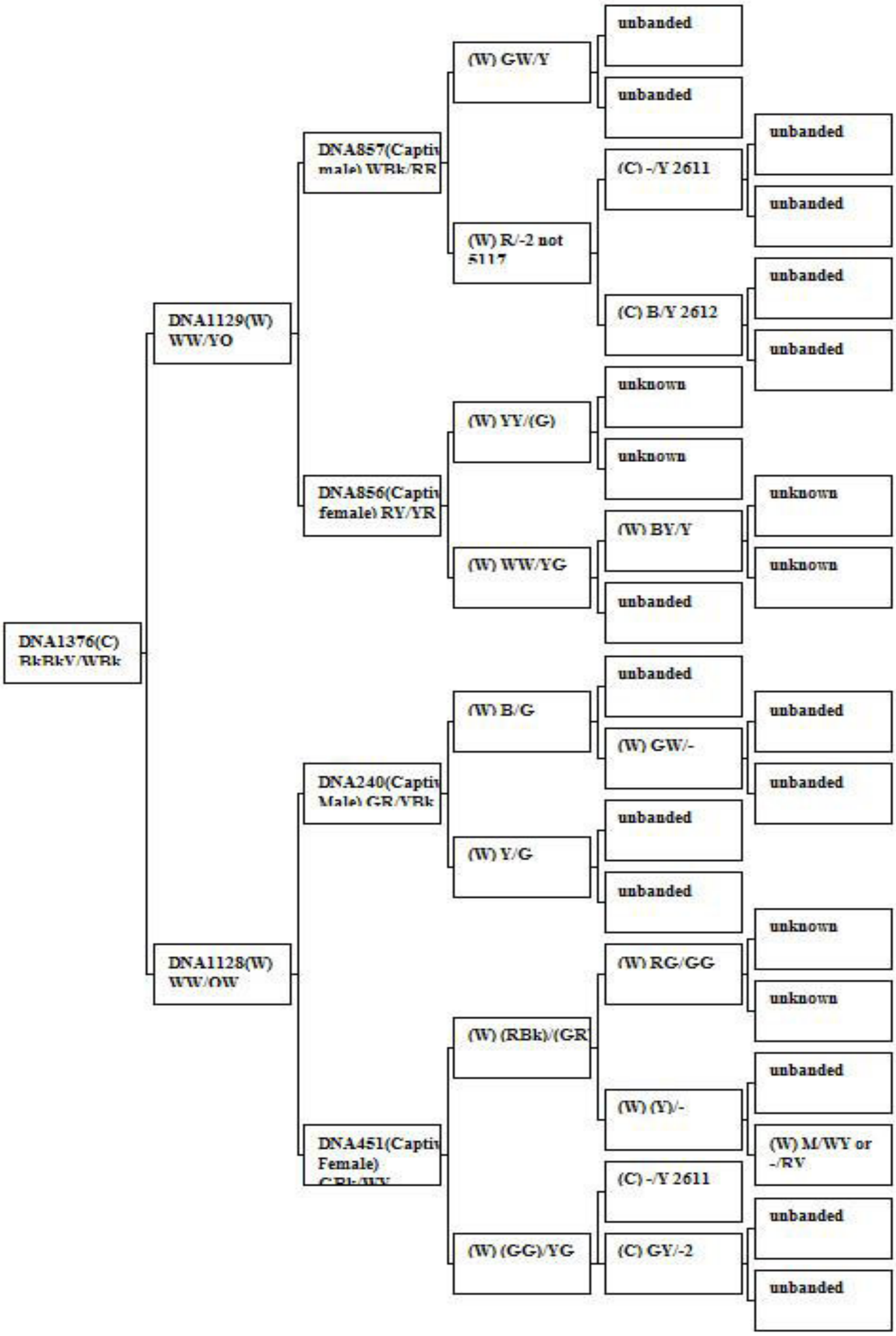

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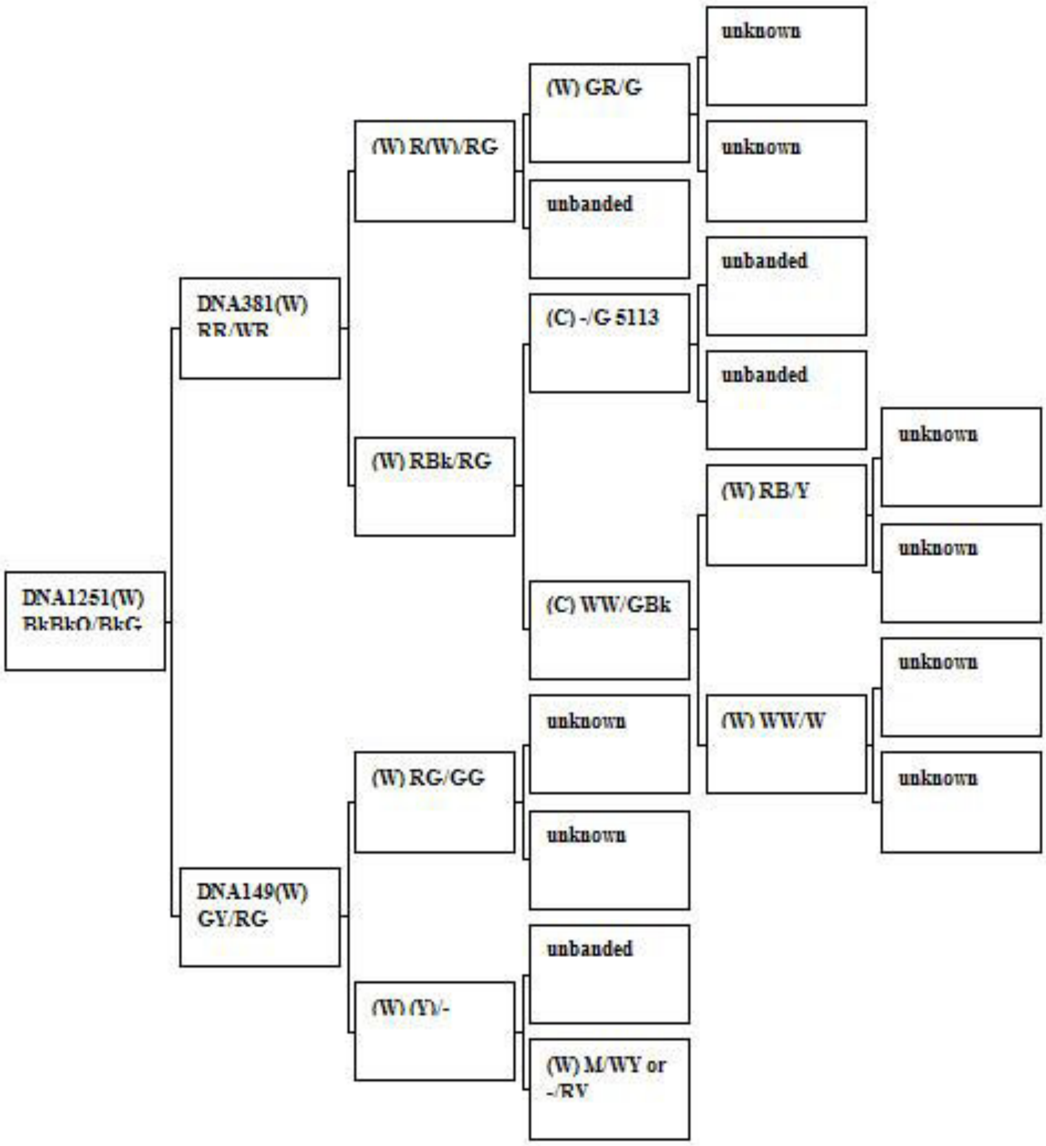

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