Breeding Focus 2016 – Improving Welfare

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Preface

The inaugural 'Breeding Focus' workshop was held in 2014 to outline and discuss avenues for genetic improvement of resilience. The Breeding Focus workshop was developed to provide a forum for exchange between industry and research across livestock and aquaculture industries. The objective of Breeding Focus is to cross-foster ideas and to encourage discussion between representatives from different industries because the challenges faced by individual breeding organisations are similar across species. This book accompanies the Breeding Focus 2016 workshop. The topic of this workshop is 'Breeding Focus 2016 - Improving welfare'.

> *"Animal welfare means how an animal is coping with the conditions in which it lives. An animal is in a good state of welfare if (as indicated by scientific evidence) it is healthy, comfortable, well nourished, safe, able to express innate behaviour, and if it is not suffering from unpleasant states such as pain, fear, and distress. Good animal welfare requires disease prevention and veterinary treatment, appropriate shelter, management, nutrition, humane handling and humane slaughter/killing. Animal welfare refers to the state of the animal; the treatment that an animal receives is covered by other terms such as animal care, animal husbandry, and humane treatment."* (World Organisation for Animal Health 2008).

Animal breeding offers opportunities to improve the state of animals. Existing methodologies and technologies used in animal breeding can be used to improve welfare of animals on farm while maintaining productivity. Welfare and productivity are not necessarily in opposition because several welfare measures are genetically independent from productivity traits. Further, it is often economically beneficial to improve welfare traits. These aspects provide ample opportunities to improve both welfare and productivity through selective breeding.

The chapters of this book describe existing frameworks to define welfare of animals and outline examples of genetic improvement of welfare of farm animals. A reflection on ethical issues of animal breeding and welfare is presented and further avenues for genetic improvement of welfare are discussed.

We thank all authors for their contributions to this book and their presentations at the Breeding Focus 2016 workshop in Armidale. Each manuscript was subject to peer review by two referees. We thank all reviewers who generously gave their time to referee each book chapter. A special thank you goes to Kathy Dobos for looking after all details of organising this workshop and for her meticulous work on putting this book together.

Susanne Hermesch and Sonja Dominik

Armidale, September 2016.

Farming dinosaur cousins: the unique welfare challenges of farming crocodiles

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Abstract

In the last five decades, the Australian saltwater crocodile population has recovered from near extinction back to pre-hunting levels because of a highly successful conservation strategy. Farming has been crucial in the recovery by providing economic-incentives to landowners to conserve the species and its habitat. However, farming a species that has evolved little since the dinosaurs has unique challenges compared to traditional livestock species. The lack of selection and domestication (wild harvested eggs) equates to large phenotypic variation and, given the industry's infancy, has relied on developing husbandry approaches that balance the physiological needs of crocodiles and production outputs. This approach appears to have successfully satisfied the welfare needs of the crocodiles although improvements are continually being sought. Novel equipment and handling techniques have been developed to ensure safe working environments for staff whilst maintaining animal welfare. The primary product is the skin, which is also unique as skins/hides are normally a by-product of traditional farming operations. This brings more idiosyncratic challenges as buyers demand blemish-free skins that will produce flawless high-end fashion products. Overall, in a short period of time, the Australian crocodile industry has emerged as an economically-viable, sustainable conservation-based industry but still has many challenges ahead as we continue to learn about the husbandry and welfare requirements of these dinosaurian descendants.

Introduction

Birds and crocodilians are the two extant clades of archosaurs which included dinosaurs and pterosaurs (Green *et al*. 2014). While birds and crocodiles diverged more that 240 million years ago, members of the Order *Crocodylia* , consisting of crocodiles, alligators and gharials, have remained relatively unchanged morphologically and ecologically (Green *et al*. 2014). They are apex predators, but the value of their skin meant that populations worldwide were hunted to near extinction until the implementation of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in 1975 (Webb *et al*. 2013). Since then, sustainable use programs have led to the recovery of many crocodilian species, including the Australian saltwater crocodile (*Crocodylus porosus*) population, which is the focus of this chapter.

In the Northern Territory and Western Australia, sustainable use is based on the collection of eggs from the wild with subsequent incubation, hatching and raising in captivity, known as "ranching" (Saalfeld *et al*. 2015). Some farms in the Northern Territory and Western Australia also have captive breeding crocodiles to supplement wild derived hatchlings. In Queensland, hatchlings can only be derived from captive breeding although some farms have overcome this by importing wild-harvested eggs/juveniles from other states. The resultant hatchlings are raised to supply skins for the manufacture of luxury fashion items (Finger *et al*. 2015c). However, farming crocodiles presents unique challenges compared to traditional farming species, particularly when considered together, including:

- no domestication (wild harvest)
- carnivore (apex predator)
- ectotherm requiring the ability to behaviourally thermoregulate
- semi-aquatic; and
- skin as the primary product.

No domestication

Crocodile farming began in Australia in 1971 (Webb *et al*. 2013) but prospects for a viable industry began in the 1980's when the Australian population of saltwater crocodiles were moved from Appendix I to Appendix II of CITES (Saalfeld *et al.* 2015). Being on Appendix II ratifies the ability to implement sustainable harvesting as a conservation strategy since Appendix I only allows trade of captive bred individuals (MacGregor, 2002). As a result of being able to secure stock, the number of farms and the number of crocodiles within those farms have grown along with the recovery of the wild populations across northern Australia (Webb *et al*. 2013). There are currently approximately 185,000 crocodiles on Australian farms.

While harvesting eggs and adults for breeding from the wild has been an effective conservation strategy, it means that no selection for performance ability under intensive production systems can be undertaken. Isberg *et al*. (2004; 2005a; 2005b; 2006a; 2006b) assessed the potential of implementing genetic improvement noting that there were substantial economic benefits to be gained from exploiting the genetic variation. For example, heritability estimates for survival for crocodiles are much higher (animal model = 0.28 – 0.60) than those reported for many other production species (Isberg *et al.* 2009). However, with the infancy of the industry, the emphasis so far has been on a) hatchling recruitment to achieve economies of scale for a viable industry, and b) optimisation of husbandry and welfare (e.g. pen design, nutrition, temperature, disease management, skin quality, etc.).

The "Code of Practice on the humane treatment of wild and farmed Australian crocodiles" (Code of Practice; NRMMC, 2009) was developed based on the husbandry literature, current at that time, and defines minimal requirements for best ethical practice. However, until published results by Finger *et al*. (2015a; 2015c) no studies had quantified the standards defined by the Code of Practice. Finger *et al*. (2015a; 2015c) used corticosterone (glucocorticoid; CORT) along with immune parameters, steroid hormones and growth parameters to assess stress at three different sampling times within the first year post-hatch. Overall, CORT levels were the lowest ever reported in saltwater crocodiles and comparable to American alligators, previously considered unattainable. Interestingly, given the data were repeated measures, Finger *et al.* (2015a) were able to demonstrate a significant decline in CORT variability at nine months of age compared to three and six months (Fig. 1). Is this quantifying hatchling habituation? These hatchlings were derived from on-farm nests but from wild-harvested adult crocodiles, so no domestication or selection had taken place in the breeding population. In the overall analysis, no significant clutch effect was observed, but when the data were subset by time after hatching the CORT results at three months showed significant clutch effects. In birds, maternal transfer of CORT *in ovo* has demonstrated effects on many post-hatching characteristics including growth and survival (Hayward and Wingfield, 2004; Saino *et al*. 2005). Work is continuing to show if there is a relationship between maternal-yolk CORT transference or if potential epigenetic effects exist. The results could prove useful to either assess breeding crocodile welfare or develop selection tools for habituation.

What if your stock wanted to eat you?

Crocodiles are the only farmed species that could actually consider their keepers to be prey and all too frequently, wild saltwater crocodile attacks, sometimes resulting in human fatalities, are tragically reported (CrocBITE 2013). The development of specialised equipment to ensure safe work practices and vigilance of management and staff when structuring work programs has meant Australian crocodile farms report few work health and safety injuries each year (Safe Work Australia, 2015). For example, traditionally larger crocodiles in the production system (>1m) were caught using a rope attached to the end of a very long pole looped over the top jaw. The crocodile was then physically exhausted before the top and bottom jaws were secured together for safe handling (manual restraint). After release, these crocodiles would often not eat for some days, which was indicative of stress and in a farm setting meant wasted food and labour as well as no growth conversion (Franklin *et al*. 2003). As an alternative, an electro-stunning device was developed that delivers a short charge (approx. 6 seconds at 110V) to the back of the neck which stuns the crocodile for 5-10 minutes allowing farm staff to safely secure the jaws without risk of injury (Davis *et al.* 2000). Compared to manual restraint, electro-stunned crocodiles exhibited a lower magnitude of stress response and faster return to baseline levels (Franklin *et al*. 2003; Pfitzer *et al*. 2014).

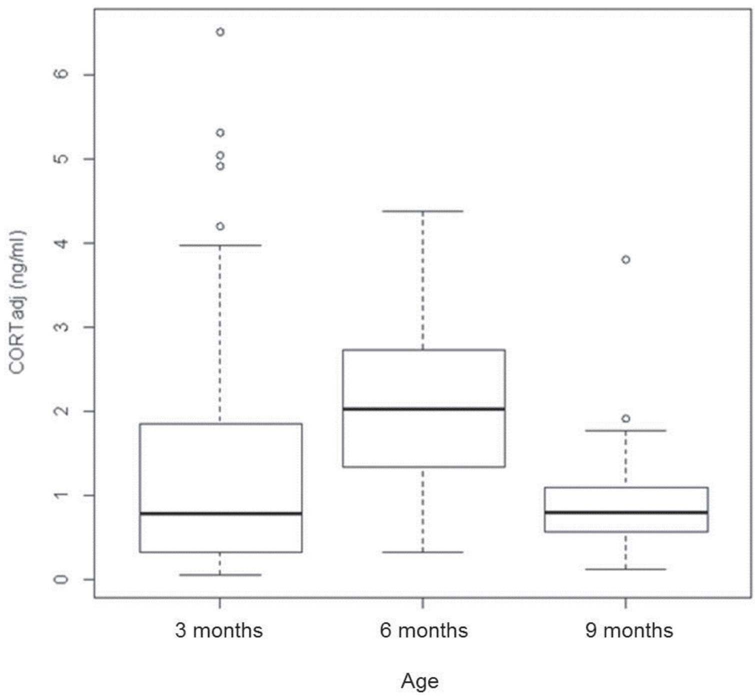

Figure 1. Box-plot of time-adjusted plasma corticosterone (CORTadj) showing the means and variation between sampling ages (adapted from Finger et al. 2015a)

Defining, understanding and quantifying important behavioural traits of crocodiles under commercial propagation are limited. Brien *et al.* (2013) have pioneered this field and reported the establishment of dominance hierarchies within 13 weeks of hatching characterised by aggression-submission interactions. They noted that significant clutch differences in agonistic behaviours were noticeable from as early as one week and could represent an opportunity for the selection of desirable domestication traits if a correlation with important production traits, such as growth, were known. Without behavioural observations, Finger *et al.* (2015c) questioned whether growth was determined by plasma testosterone levels which could, in turn, influence aggression (Morpurgo *et al.* 1993). Unexpectedly, crocodiles with higher growth rates had lower testosterone levels. The heritability of testosterone was calculated to be 0.22 (SE ± 0.20; Finger *et al.* 2015b) suggesting that testosterone could be a potential heritable biomarker for growth, but requires the inclusion of behavioural observations before selection strategies can be developed.

Ectothermic and semi-aquatic

With the exception of frogs, no other production species are both ectothermic (cold-blooded) and semi-aquatic. This presents distinctive challenges in relation to pen design, resource provision and, predominantly, heat provision. Mortality statistics and disease-husbandry associations in the first decade of crocodile farming reported weighted average mortality rates on three Northern Territory farms were greater than 30% with higher incidences evident during the dry season (winter months; Buenviaje *et al*. 1994). Of these, Buenviaje *et al*. (1994) classified opportunistic bacterial septicaemia/hepatitis, superficial and deep mycosis, renal gout and pentastomiasis as the major diseases.

Since then, 32°C has been found to be the optimum water temperature to raise hatchling saltwater crocodiles (Turton *et al.* 1997) along with a temperature gradient that allows individuals to behaviourally thermoregulate (references within Brien *et al.* 2012). As a result of improved management, average hatchling mortality rates have drastically declined (13.4%; Isberg *et al.* 2009). The majority of deaths (48.7%) are due to runting for which the cause is still unknown (Shilton *et al.* 2014) but is most probably (maternal) genetic influenced (Isberg *et al.* 2009; Finger *et al.* 2015a). In contrast, the number of deaths related to disease (1.6%) and known stressors (e.g. grading, moving; 0.98%) are comparatively low.

Given the wild-harvest strategy, producers are not able to proactively select on survivability at this stage. Finger *et al.* (2015a) assessed the use of bacterial killing assays as an appropriate selection tool to quantify innate immune response using *Providencia rettgeri* which is the bacterium responsible for most septicaemic mortalities. The heritability varied with age but was high (0.31–0.75) showing the potential for selection. However, conducting bacterial killing assays is not without challenges. Thus, the strong negative genetic correlation of this trait and plasma testosterone (-0.80 ± 0.26) may prove useful as an alternative selection criterion (Finger *et al.* 2015b).

Skins as the product

Crocodiles are farmed predominantly for their belly skins to be manufactured into high-end fashion products. Saltwater crocodile skins are revered due to their small scale size, even scale distribution, large overall belly area and lack of bony deposits (osteoderms) within the skin (Manolis and Webb 2011). However, saltwater crocodile skins represent only a small proportion of crocodile skins traded worldwide and must compete alongside Nile crocodile and American alligator skins. To be accepted by the fashion houses, the skin must be flawless. This means that the skin cannot show any imperfections from scratches or scrapes that may have been incurred during the production process.

Unpublished data suggests that the majority of these blemishes are superficial scratches and punctures that affect only the upper keratin (scale) layer, although some do penetrate deeper into the underlying epidermis and dermis. As such, most seem to be incurred by non-aggressive interactions with conspecifics within communal pens (Isberg and Shilton 2013). Consequently, to allow any imperfections to heal, crocodiles are placed into individual finishing pens for the last stage of production. These pens were designed after considering the five freedoms (Farm Animal Welfare Council, 2009) as they relate to crocodiles. As a result, housing harvest size (1.6-1.8m) crocodiles individually produced no significant differences in CORT levels to those housed communally (Isberg and Shilton 2013). Given low CORT levels are also essential for maximal blemish healing rates (Morici *et al.* 1997; Lance *et al.* 2000), the welfare of crocodiles is of economic importance.

Grading standards have tightened substantially in the years since the 2009 global financial crisis (demand) and as more skins have entered the marketplace (supply). Many of the defects causing the downgrading cannot be seen on the live animal but instead become apparent at the "in-crust" stage of tanning (Manolis and Webb 2011) when the keratin (scale) has been removed and the pigmentation removed. Skin graders now universally use tables with a light underneath. Many defects that will be seen in-crust can be identified as a lucent area despite having a normal contour and intact keratin. Understanding blemishes, their aetiology, prevention and ability to heal is currently the focus of considerable research effort.

Summary

The crocodile industry is still evolving since its inception five decades ago. At the forefront of this evolution is the need to understand the drivers of crocodile welfare. Australian crocodile producers are acutely aware that to achieve maximal production outputs, they must understand the unique physiology and idiosyncrasies of their stock and cater to them. There has been a considerable shift in culture away from needing to over-power crocodiles with brute strength. Instead, crocodiles can be handled calmly, and with their welfare in mind, which translates to less stress, fewer disease problems, minimal mortality and better skin quality, while ensuring a safe workplace for staff. However, it must be remembered that crocodilians are very different to traditional livestock species and the direct transference of welfare standards may also be inappropriate.

Wild-harvesting crocodile eggs to raise in captivity for commercial skin production has proven to be a highly successful conservation strategy with benefits to the species, landowners, indigenous economic development, industry employment and infrastructure as well as filling a market demand that was historically been filled using unregulated and unsustainable sources. The disadvantage of this strategy from the production perspective is that no genetic selection can take place in a conventional sense by selecting juveniles to become the next breeding generation. However, that should not limit the possibility of exploiting genetic potential. Developing *in ovo* and post-hatch genetic selection tools could provide producers with the opportunity to screen crocodiles to determine their suitability before being placed onto farm.

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