Economic values for skin grade, days to market and number of hatchlings in the Australian saltwater crocodile industry

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Abstract

The saltwater crocodile industry in northern Australia produces skins for high-value leather products. Most eggs are harvested from the wild, providing multiple livelihood benefits to rural and Aboriginal communities in the area. Economic values derived from an independent model for each trait were AU$620.40 for skin grade (a binary trait), AU$-0.95/day for days to market and AU$105.30/hatchling for number of hatchlings per clutch. Economic values were converted to economic weights expressed on the basis of a clutch of the breeding female for a comparison among traits. Based on phenotypic standard deviations of traits, skin grade had the highest emphasis (50%) followed by days to market (38%). Economic values derived in this study should be used to assist management decisions. Setting up structured breeding programs for saltwater crocodiles in northern Australia is less desirable given the wider benefits of harvesting eggs from the wild for rural and Aboriginal communities.

Introduction

The saltwater crocodile industry in northern Australia produces skins for high-value leather products. Saltwater crocodile eggs are collected from the wild, under approved management programs, providing multiple livelihood benefits for rural communities (Fukuda and Webb, 2019, DEPWS, 2020). Harvesting eggs relies heavily on traditional Aboriginal knowledge and royalties are paid for each egg collected, placing economic worth on an apex predator. This sustainable-use model has contributed to full species recovery and conservation of the habitat and co-existing species. Further, the saltwater crocodile industry provides jobs and income to rural communities in remote areas where other income sources are scarce. Fukuda and Webb (2019) also point out "a key threat, however, to both wild crocodiles and Aboriginal livelihoods, is recent moves by some actors in the fashion industry to stop using wild crocodilian skins."

The crocodile industry can only provide livelihood benefits to rural communities if it is profitable. Profitability can be increased by improving traits of economic importance. Economic values define economic importance of traits and have been used extensively in animal breeding. However, they may also be used to evaluate alternative management strategies to improve profitability. So far, information about economic values in the crocodilian industry is sparse (Gray *et al*. 2007) and adoption has been hindered by lack of information about input values and specific setup of bio-economic models. The use of independent models (e.g. Amer *et al*. 2014) provides greater flexibility in trait selection for breeding, and management, objectives. The aim of this study was to develop independent economic models to derive economic values for key performance traits in saltwater crocodiles in the Australian context.

Materials & Methods

Economic values for skin grade, days to market and number of hatchlings per clutch were derived based on an independent economic model for each trait. The components of these economic models reflect relevant crocodile farming practices which are not widely known and some background information is provided. More detailed information about saltwater crocodile farming and trait definitions was provided by Isberg *et al*. (2005 a,b).

Skin grade. Skins are sold on a "per cm belly width" basis and returns per crocodile increase linearly for every additional cm in belly width. However, the maximum price received is only obtained for first-grade skins and price is substantially reduced depending on the number and location of any imperfections. Skin grade was defined as a binary trait defining whether skins meet requirements for the first grade (1) or were part of the other grades (0). The economic value for skin grade (EVsg) was derived as: EVsg = (Rsg1 – Rsg0) where Rsg1 was the return for first-grade skins and Rsg0 was the average return for skins in the other three grades. The return per first-grade skin was AU$1,504 based on a payment of AU$40/cm and an average belly width of 37.6 cm (Isberg *et al*. 2005b). The average return for skins from the other grades was AU$883.6 based on prices of AU$30, AU$10 and AU$0 per cm for the second, third and fourth skin grades, respectively, which were assumed to represent the same average dimensions and comprise 15%, 2% and 3% of skins.

Days to market. Days to market quantifies the number of days from birth until the age when crocodiles reach market size. Market size is determined by belly width, rather than weight, and saltwater crocodiles are slaughtered when they have reached a belly width of 35 to 45 cm. In northern Australia, saltwater crocodiles hatch from January to July and stay in the hatchling facility until the end of each calendar year, when they are moved to the overall grow-out facilities. Days to market therefore encompasses the hatchling phase and the grower phase. The economic value for days to market (EVdays) was: EVdays = - (Vm – Cm – Ch) / days where Vm was the average market value per crocodile (AU$1,380) based on the assumptions of classification and payments of skin grades outlined above, Cm were the marketing costs per crocodile (AU$ 284) and Ch were costs to produce a hatchling (AU$ 107.3), while days was the number of days to reach market size (1037.8 days).

Number of hatchlings. Despite the Australian crocodile industry relying heavily on wild egg collection with the primary aims of species conservation and rural livelihood benefits, farms often keep a small nucleus of breeding animals. These breeding crocodiles have been removed from the wild as problem crocodiles, as part of the public relations program of promoting living with an apex predator (DEPWS, 2020). However, no performance selection has occurred and there is an opportunity to optimise future breeder selection and increase farm profitability.
Each female produces one clutch of eggs per year, which are then incubated. Breeding pens vary in their stocking density but mainly consist of one male with one to eight females. Others simulate more natural breeding populations with multiple males and multiple females. Each crocodile farm can produce a fixed number of hatchlings each year due to market constraints and an increase in clutch size would lead to cost savings in the number of females required to produce the target number of hatchlings. The economic value for number of hatchlings (EVnh) was: EVnh = Cf / nh – Clh where Cf was the sum of all annual cost of breeding females (Cf), nh was the number of live hatchlings per clutch (nh: 31.25, Isberg *et al*. 2005a) and Clh was additional labour cost for an additional hatchling (AU$0.96). Costs per female included costs for capital (AU$1,122), labour (AU$1,278) and feed (AU$780) based on one female per male in each breeding pen.

Economic weights. Economic values were derived for two traits of growing crocodiles and a trait of breeding females expressed per clutch, which differ in frequency and timing of expression. These differences were considered through discounted genetic expressions (DGE) to convert economic values of traits of growing crocodiles into economic weights of a breeding objective at the time when number of hatchlings per clutch is expressed. The DGE was derived as: DGE = nh * surv / {(1+r)^(days / 365)} where nh was the number of hatchlings per clutch (31.3), surv was the survival rate of hatchlings until slaughter (81%) and r was discount rate (0.07). The economic weight of each trait was multiplied with the corresponding phenotypic standard deviation to express each trait emphasis relative to the sum of these products. In animal breeding, this illustration of trait emphasis is usually based on genetic standard deviations which are currently not available for these crocodile traits and phenotypic standard deviations were used instead.

Results

The proportion of first-grade skins was assumed to be 0.8 and the standard deviation of this binary trait was derived (Table 1). First heritability and repeatability estimates for the other two traits were moderate to high. Economic weights expressed relative to the phenotypic standard deviation of traits were highest for skin grade (50%) and days to market (38%, Figure 1).

Table 1. Data statistics, repeatability or heritability (ratio where known) as well as economic values (EV) and economic weights (EW) for saltwater crocodile traits.

Trait	Mean	SD	ratio	EV	EW [4]
	Traits of growing crocodiles				
First-grade skins (1/0) [1]	0.8	0.40		620.40	12,915.70
Days to market (days) [2]	1037.8	197.77	0.40	-0.95	-19.83
	Trait of the female (clutch)				
Number of hatchlings [3]	31.3	11.45	0.34	100.80	100.80

[1] Data statistics derived for a binary trait and heritability is unknown
[2] Data statistics from Isberg *et al.* (2005b), heritability presented
[3] Data statistics from Isberg *et al.* (2005a), repeatability presented
[4] The discounted genetic expression to convert EVs of traits of growing crocodiles traits to EW expressed per clutch (AU$/clutch) was 20.82.

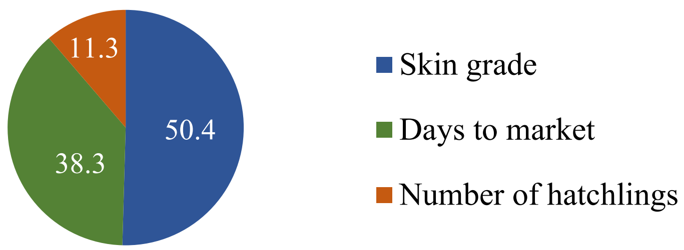

Figure 1. Percentage emphasis of crocodile traits based on phenotypic variation of traits.

Discussion

Crocodiles are placed into finishing pens when they are appraised to be close to market size. The number and severity of imperfections on the belly skin determines the amount of time they spend in the finishing pens. Environmental influences such as floor surfaces, hygiene practices and prevalence of mosquito-borne viruses may override expression of underlying genetic variation for skin grade. Given the economic importance of skin grade, this trait should be recorded more closely on farms to identify genetic and non-genetic factors affecting the trait.
Skin grade determines the price per cm belly width obtained for each crocodile skin and a higher belly width leads to higher returns. Further, Gray *et al.* (2007) illustrated a payment system which rewarded larger belly width in the first skin grade while prices for belly width in other

skin grades remained constant. This type of payment system can be considered when deriving economic values for both skin grades and belly width through a bivariate distribution of crocodile skins across skin grades and belly-width groups, as outlined by Hovenier *et al*. (1993) for the univariate case. However, belly width and days to market are associated and trait definitions for belly width and days to market have to ensure that these two traits are independent at both the phenotypic and genetic level. Belly width is similar to market weight in livestock, which is often assumed fixed and not considered separately to days to market in breeding objectives. These considerations need further investigation to model the economic benefits of larger belly width.

Feed costs were not modelled separately and were part of EVdays. Crocodiles require a relatively low amount of feed; e.g. adult breeding crocodiles require only one (females) or two (males) chicken each week. However, costs of feed are not negligible due to high transport and refrigeration costs and should be considered separately as a trait. Of larger consequence is the natural variation of growth rates expressed. Isberg *et al.* (2005b) reported the range in number of days to reach market size to be 634 to 1,859 days. This translates to a difference of 3.4 years in associated production costs, illustrating the potential to improve profitability.

In northern Australia, the majority of eggs to produce hatchlings are sourced from the wild-egg harvest providing income and employment to rural and Aboriginal communities. The cost of wild eggs is similar to the costs of eggs bred in captivity (EVhn) and there is no economic benefit to produce eggs on farms. Given the primary consideration to the income and employment opportunities that wild-egg harvesting provides in northern Australia, economic values derived in this study may best be used to aid management decisions on farms to improve profitability because most farms may not setup a genetic improvement program.

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References

Amer P.R., Ludemann C.I., and Hermesch S. (2014) J. Anim. Sci. 92(12):5345-5357. https://doi.org/10.2527/jas.2014-7943

DEPWS (2020). Wildlife Trade Management Plan- Crocodile Farming in the Northern Territory 2021-2025. https://www.awe.gov.au/sites/default/files/documents/nt-crocodile-farming-wtmp-2021-2025.pdf

Fukuda Y., and Webb G. (2019) Saltwater Crocodile harvest and trade in Australia. Available at: https://cites.org/sites/default/files/eng/prog/Livelihoods/case_studies/CITES_livelihoods_Fact_Sheet_2019_Australia_Crocodiles.pdf

Gray E.M., Ahmadi-Eshahani F.Z., and Isberg S.R. (2007) Aust. J. Agric. Resour. Econ. 51:57-72. https://doi.org/10.1111/j.1467-8489.2007.00362.x

Hovenier R., Brascamp E.W., Kanis E., van der Werf J.H.J. and Wassenberg A.P.A.M (1993) J. Anim. Sci. 71:1429-1422. https://doi.org/10.2527/1993.7161429x

Isberg S.R., Thomson P.C., Nicholas F.W., Barker S.G. and Moran C. (2005a) J. Anim. Breed. Genet. 122:361-369. https://doi.org/10.1111/j.1439-0388.2005.00548.x

Isberg S.R., Thomson P.C., Nicholas F.W., Barker S.G. and Moran C. (2005b) J. Anim. Breed. Genet. 122:370-377. https://doi.org/10.1111/j.1439-0388.2005.00549.x