GENETIC PARAMETERS FOR OSTRICH CHICK MORTALITY TO SIX MONTHS POST HATCH

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SUMMARY

Data of ostrich chicks were used to estimate genetic parameters for moisture loss at 35 days of incubation, time of pip, day-old chick weight and post hatching mortalities from 0 to 3 weeks, 4 to 12 weeks and 13 to 24 weeks. An animal model utilizing up to 9527 chick records from a commercial pair breeding flock in Oudsthoorn, South Africa was utilized. The fixed effects of year, hatching season, hatching group and incubator influenced all the traits. Hen age effects were significant for all the traits except for mortality after 3 months. Heritability estimates for these traits were low to moderate at respectively, 0.22, 0.14, 0.22, 0.06, 0.05 and 0.02. Only day-old chick weight was affected by a significant maternal component (0.27), while moisture loss at 35 days incubation, time of pip and day-old chick weights were influenced by a dam permanent environmental effect (0.31, 0.04 and 0.19). Early (<3 months) ostrich chick mortality exhibited significant genetic variation, albeit low.

INTRODUCTION

The ostrich production industry lacks distinct breeding objectives and industry breeding structures, while environmental and genetic influences for some key traits are unknown (Cloete *et al.* 2008). Non-genetic and genetic parameters as well as responses to selection for specific traits need to be determined for the definition of breeding objectives (Brand *et al.* 2008; Cloete *et al.* 2002; 2008). The most fundamental discrepancy pertaining to genetic parameters for performance or reproductive traits of ostriches is a lack of genetic parameters for chick mortality (Cloete *et al.* 2008). High chick mortalities, predominantly occurring during the first few months post hatch, represent a major setback within the industry (Cloete *et al.* 2001). Ostrich chicks are predisposed to various infections, diseases, disorders and stresses during the first 3 months post hatch and mortality recordings commonly range from 10-50% (Allwright 1996; Verwoerd *et al.* 1997) and around 5-10% from 3 to 6 months post hatch (Verwoerd *et al.* 1999). More systematic studies of chick mortality would assist in the development of husbandry systems that reduce stress imposed on chicks while enhancing the coping ability and resistance of the chicks. Chick survival and the commercial production of ostriches could thus be optimized (Verwoerd *et al.* 1999).

Additional knowledge of the genetic and environmental factors affecting chick mortality, as well as the traits recorded during the last week of incubation and soon after hatching would be of assistance in the development of breeding methods that could possibly enhance the survival and subsequent performance of ostrich chicks. These traits are thus reported in this paper.

MATERIALS AND METHODS

South African Black ostrich (*Struthio camelus domesticus*) data recorded from 2000 to 2006 on the Klein Karoo Research farm near Oudsthoorn, South Africa, was used. The management of the breeding pairs and the eggs has previously been discussed (Bunter and Cloete 2004; Cloete *et al.* 2008). A Microsoft Excel 2007 pivot graph showing the mortality curve relative to age of chicks was utilized to divide the data set into three respective trait groups on age at mortality. Mortality from 0 to 3 week post hatching (0T3W) comprised of 9527 records. Four to 12 week mortality

(4T12W) comprised of 6811 records and included chicks that were alive after three weeks. Mortality from 13 to 24 weeks post hatch (13T24W) involved 3227 chicks and only included those chicks that survived up to 12 weeks post hatch. The pedigree file involved 9903 individuals, that were the progeny of 257 males and 251 females that were paired of in 342 unique combinations.

Subsequent to careful editing of the data, ASREML software (Gilmour *et al*. 2006) was utilized to run single-trait analyses on age-specific mortality so that suitable fixed and random effects models could be developed. Fixed effects fitted were hen age (2 to 12+ years), year of hatch (2000 to 2006), hatching season (Winter, Spring and Summer), storage time prior to setting (1 to 8+ days), hatching group and incubator (defined by Brand *et al*. 2009). Additional analyses involved the inclusion of day-old chick weight as a linear and quadratic covariate for mortality date. Initially the logit transformation was used to link the binomial mortality data to the normal distribution. The results proved to be very similar to when the mortality data were treated as normally distributed. For ease of presentation the latter analysis was used. Random effects fitted sequentially included animal additive effects, maternal genetic effects and dam permanent environmental effects (fitted as unique dam within year). The pair-mating structure in ostriches lead to high sampling correlations between random effects, but it was still possible to partition the random effects considered, as was also reported by Bunter and Cloete (2004). Likelihood Ratio tests (LRT) determined which random term made a significant contribution to improving the respective models and the corresponding variance components were estimated. Average information algorithms concomitantly supplied standard error estimates for the genetic parameters.

RESULTS AND DISCUSSION

The mortality curve of all chicks in the data set corresponded closely to that of Cloete *et al*. (2001). Descriptive statistics for the data is represented in Table 1. A binomial trait, mortality traits had zero representing the chicks that survived, while one recorded those chicks that died. The coefficients of variation for mortality traits ranged from 95% to 165%. There is a drastic decline in the number of records as a result of mortalities occurring during the time period immediately preceding it. Mortality rose from 28.5% in the first 3 weeks post hatch to 52.3% during the 4 to 12 weeks post hatch. From there it declined again to 26.6%. Once chicks attain 3 months of age they are usually hardy and only require shelter from inclement weather and mortality tends to stabilize at a lower rate.

Table 1. Number of records (N), means, standard deviations (SD), coefficients of variation (CV) and the data range for mortality from 0 to 3 weeks (0T3W), mortality from 4 to 12 weeks (4T12W), mortality from 13 to 24 weeks (13T24W) post hatch, moisture loss after 35 days of incubation (ML35), time of external pip (TOP) and day-old chick weight (DOCW)

Trait	N	Mean	SD	CV	Range
ML35 (%)	9527	12.8	2.72	21.1	6.4 – 30.50
TOP (day)	9527	41.9	1.23	2.9	35.7 – 46.3
DOCW (g)	9527	855	102	11.9	487 – 1215
0T3W	9527	0.285	0.452	158	0 – 1
4T12W	6811	0.526	0.499	95	0 – 1
13T24W	3227	0.269	0.443	165	0 – 1

The average moisture loss up to 35 days of incubation was 12.8% and ranged from 6.4 to 30.50 %. These results are in accordance with previous findings (Brown *et al*. 1996; Brand *et al*. 2008; 2009). Day-old chick weight generally ranges from 780 to 975g (Verwoerd *et al.* 1999), although larger ranges from 464 to 1300g have been reported (More, 1996). The day-old chick weight in this analysis ranged from 487 to 1215g with an average weight of 855.3g. This corresponds well to other findings on the same resource flock (Cloete *et al*. 2001; Bunter and Cloete 2004; Brand *et al*. 2008). The time of pip ranged from 35.7 days to 46.3 days with a mean of 41.85 days. This mean falls between the 41.3 days and 42 days, as reported by Cloete *et al*. (2001) and Brand *et al*. (2009) respectively.

Fixed effects. Table 2 represents the fixed effects fitted for the traits. Year, hatching group and incubator were significant for all traits ($P < 0.05$). Hen age significantly affected mortality to 3 months, moisture loss, time of pip and day-old chick weight ($P < 0.05$). Storage time affected the incubation traits (moisture loss, time of pipping and day-old chick weight), as well as early chick mortality, while hatching season affected all traits but mortality from 0 to 3 weeks.

Table 2 P-values of the respective fixed effects (ns=not significant). Fixed effects were hen age (HAGE – 11 levels; 2 to 12+ years), year (YR – 7 levels; 2000 to 2006), hatching season (HS – 3 levels; Winter, Spring and Summer), storage time (STIME – 1 to 8+ days), hatching group (HGR – 32 level) and incubator (INC – 5; as defined by Brand *et al*. 2009)

Trait	HAGE	YR	HS	STIME	HGR	INC
ML35 (%)	<0.001	<0.001	0.013	<0.001	<0.001	<0.001
TOP (day)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
DOCW (g)	<0.001	<0.001	0.002	<0.001	<0.001	<0.001
0T3W	0.019	<0.001	ns	0.031	<0.001	<0.001
4T12W	0.015	<0.001	<0.001	ns	<0.001	<0.001
13T24W	ns	<0.001	<0.001	ns	<0.001	0.005

Random effects. Due to high sampling correlations between the sires and dams typical of the pair-breeding system (Bunter and Cloete 2004), the partitioning of the covariance between the direct and the maternal effects (ram) was not attempted. Although both the maternal genetic and dam permanent environmental effects were initially fitted for the mortality traits, neither contributed significantly. These effects were thus excluded from the final models. These results were not entirely unexpected, as ostrich chicks are reared artificially in the absence of parental care. Day-old chick weight was the only trait that had a significant maternal component, while dam permanent environmental variation was significant for moisture loss at 35 days incubation, time of pip and day-old chick weight.

The estimates of the genetic parameters for each of the traits together with their standard errors are represented in Table 3. The heritability estimates for mortality during the first 3 months was low, but higher than twice the corresponding standard error. Selection for a reduced mortality within the first 3 months post hatch could thus play a role in average flock performance. However mortalities from 13 to 24 weeks of age did not seem to be under genetic control, suggesting that such mortalities were of a coincidental nature opposed to being governed by genes. It is conceded that mortality data at later ages were severely censored, which could have masked some genetic variation. The importance of this phenomenon should be investigated in further multi-trait analyses. No previous studies on the heritability of chick mortality were found to relate these results to. However, early studies on chickens suggested heritability estimates of the same magnitude for post-hatch survival (see review by Kinney 1969). The inclusion of day-old chick weight had a marginal effect upon the heritability of mortality from 0 to 3 weeks (0.07 ± 0.02 compared to 0.06 ± 0.01 in Table 3), while estimates for subsequent chick mortality were unaffected. Heritability and dam permanent environment estimates and standard errors for moisture loss at 35 days incubation accorded with those of Brand *et al*. (2009) (respectively 0.27

and 0.29). The direct heritability of day-old chick weight was in the range from 0.13 to 0.34 reported in the literature (Bunter *et al*. 1999; Bunter and Cloete 2004; Brand *et al*. 2009). The maternal genetic and dam permanent environmental variance ratios for day-old chick weight were consistent with ranges of respectively 0.28 to 0.31 and 0.13 to 0.31 in the literature (Bunter *et al*. 1999; Bunter and Cloete 2004; Brand *et al*. 2009). Parameter estimates for time of pip was consistent with corresponding estimates of 0.16 for the direct heritability and 0.04 for the dam permanent environmental effect, as reported by Brand *et al*. (2009).

Table 3. Estimates for direct heritability (h^2), the maternal genetic effect (m^2), the dam permanent environment (c^2) and the phenotypic variance (σ^2) for 0 to 3 week mortality (0T3W), 4 to 12 week mortality (4T12W), 13 to 24 weeks mortality (13T24W), moisture loss at 35 days incubation (ML35), time of pip (TOP) and day-old chick weight (DOCW)

Trait	h^2	m^2	c^2	σ_p^2
ML35 (%)	0.22 ± 0.06	-	0.31 ± 0.04	6.58
TOP (day)	0.14 ± 0.04	-	0.04 ± 0.02	1.23
DOCW (g)	0.22 ± 0.06	0.27± 0.14	0.19 ± 0.13	9482
0T3W	0.06 ± 0.01	-	-	0.19
4T12W	0.05 ± 0.02	-	-	0.22
13T24W	0.02 ± 0.02	-	-	0.16

CONCLUSIONS

This preliminary study suggested that ostrich chick mortality to 12 weeks of age exhibited genetic variation, albeit it at fairly low levels. Further studies are required to ascertain how this genetic variation can be exploited to ensure that chick mortality in the industry is reduced. The genetic correlations of other hatching and incubation traits with chick mortality should also be considered to investigate their possible application as indirect selection criteria.

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