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The performance of farmed ostrich hens in eastern Australia

Simon J. More [1]

Farm Animal Medicine and Production, The University of Queensland, PO Box 125, Kenmore 4069 Australia

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Abstract

A prospective observational epidemiological study was undertaken in the south-eastern region of Queensland in eastern Australia to collect accurate information on the performance of farmed ostriches, and to identify the most important constraints facing on-farm production. This paper (the first in a series of three) focuses upon aspects of the general study design and the productivity of ostrich hens on 12 farms in this region. These farms were a convenience sample and were visited regularly for at least 12 months from July 1993. Some general farm information was collected using a questionnaire; however, the focus of the study was mainly upon the performance of defined cohorts of hens (a cumulative total of 61 hens), eggs (910 eggs) and chicks (394 chicks). A number of methods was used to improve data quality. The study farms were managed by producers with a median of 2.5 years of active ostrich industry involvement, reflecting the recent establishment and rapid growth of the industry in this region. During the study period, 61 hens were observed for a period of 41.1 hen-years. Most hens were young (median age 2.7 years at the end of the observation period) and held in pairs. Egg production was poor, with the more-productive hens significantly older than those less-productive. Egg laying among the more-productive hens was clustered in time, with half of all eggs being laid within 2 days of a previous egg. Clutches of eggs were generally small (weighted mean 3.5 eggs) but were laid frequently (weighted mean 9.4 days between clutches). The farm and hen prevalences of *Libyostrongylus douglassi* infection were 33% and 40%, respectively.

Keywords: Ostriches; Australia; Hens; Health and productivity profile; Productivity

[1] Tel: +61 7 3365 5767; Fax: +61 7 3365 5699; Email: s.more@mailbox.uq.edu.au.

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1. Introduction

The farming of domesticated ostriches was believed to have started in southern Africa during the 1860s, primarily for the production of feathers for the fashion industry (Jensen et al., 1992, pp. 5–7; Deeming, 1993). This industry also became established in Australia at least 90 years ago, with mention being made of ostrich farming in the Coonamble and Gilgandra regions of north-western New South Wales in 1905 (Anonymous, 1912). The ostrich plume industry subsequently faltered as a result of World War I and a staggering international economy (Jensen et al., 1992, pp. 5–7), and it is only in the last 15 years that this industry has become re-established in Australia. Although the Australian industry has not yet commenced commercial slaughtering, it has attracted considerable national interest (particularly from investors) and is experiencing rapid expansion in numbers both of producers and of birds. The current industry focus is upon the production of high quality leather and meat.

The long-term success of this re-emerging industry will depend heavily upon the on-farm productivity of these birds, and the development and maintenance of international markets for the commodities that are produced. In terms of the former, there is an urgent need for an objective understanding of the current level of health and productivity of this livestock population. Such information is essential for the identification of problems, and to enable the rational development of solutions and strategies for improvement or control. It is of concern, therefore—although not unexpected given the youth of this re-emerging industry throughout much of the world—that little relevant published information is available.

This paper describes the application of a prospective observational epidemiological study (known as a health and productivity profile) to the farmed ostrich industry in south-eastern Queensland in eastern Australia. Health and productivity profiles have been used previously with cattle (Pullan, 1979), buffalo (Leidl et al., 1989), small ruminants (Faugère et al., 1991) and poultry (Wilson, 1979), and provide perhaps the most comprehensive epidemiological study method for assessing the productivity and health status of livestock populations (Morris and Leidl, 1993). The technique has been used most commonly with animals owned by smallholder farmers in developing countries; however, it is also well suited to the Australian ostrich industry which has considerable producer involvement and relatively few birds per producer.

The main objective of this study was to collect accurate information on the performance of farmed ostriches in south-eastern Queensland. This baseline information was also used to identify the most important on-farm constraints to productivity facing the farmed ostrich industry in this region. This paper describes the general design of the study and presents results relevant to the performance of ostrich hens.

2. Materials and methods

2.1. General study design

Observational epidemiological methods were used in this prospective study.

All ostriches held on farms owned and/or managed by members of the Queensland branch of the Australian Ostrich Association (A.O.A.) and within 100 km of western

Brisbane were considered the reference population of this study. This area covers much of south-eastern Queensland and also a very small portion of north-eastern New South Wales. The individual hens, eggs and chicks were the primary units of interest.

In May and June 1993, an introductory letter and subsequent follow-up telephone call was used to identify ostrich farms that met each of the following selection criteria: owned or managed by producers who were both financial members (current on 23 April 1993) of the A.O.A. (Queensland branch) and willing to participate in the 18-month study, located within 100 km of the western suburbs of Brisbane, and had at least one pair of ostriches of at least 18 months of age. All farms that met these criteria were enrolled as study farms.

On each study farm, hens were enrolled into the 'hen cohort' if, at any time during the period 1 July 1993 to 30 June 1994, they were penned with at least one male bird for the purpose of producing fertile eggs. Enrolled birds were removed from the cohort if for any reason these conditions ceased to be met. The 'egg cohort' comprised all eggs laid by enrolled members of the hen cohort. These eggs remained under observation until each hatched, was permanently removed from the incubator unhatched, or reached the 46th day of incubation without hatching (whichever occurred first). Every chick which hatched from eggs within the egg cohort was then enrolled in the 'chick cohort' and was subsequently observed until dying, leaving the study farm of origin or reaching 4 months of age (whichever occurred first).

Visits were made at 4–7 week intervals by the author to each of the study farms during the period July 1993–July 1994. To complete observations of the egg and chick cohorts, visits to five farms continued until as late as December 1994.

2.2. General methods of data collection, management and analysis

At the initial visit to each farm, a standard questionnaire, with an open-ended question design, was used to collect some general information concerning each producer, the facilities and the management practices of relevance to maintaining adult birds, incubating eggs and raising chicks. If more than one person owned or managed the birds, the questionnaire (and subsequent questions relating to the producer) was directed to the person most directly associated with the care of the birds. During this visit, measurements were taken of a single pen that was randomly selected (by drawing pen numbers from a hat) from all pens that contained a single cohort hen.

Throughout the study period, data were collected on all members of the hen, egg and chick cohorts by the producer (on simple data collection sheets), and at the first and each subsequent farm visit by the author with further questioning. The questionnaire and data collection sheets are available on request.

Following each farm visit, data were entered directly into computer datafiles. The information from this study was managed using dBASE IV version 1.5 (Ashton Tate, Scotts Valley, CA), and separate files were developed for farm demographics, individual hen and breeding-group information, individual egg information, egg weights, individual chick information, and chick weights. At the end of the field aspects of this study, and once data entry was completed, the files were transferred to SAS release 6.04 (Statistical Analysis Systems Institute Inc., Cary, NC). At this stage, data entry errors were identified by creating frequency distributions of variables, and unusual and outlying values were rechecked against the original data collection sheets. The data were subsequently analysed using Statistix version 4.0 (Analytical Software, Tallahassee, FL) and SAS. Two-sided *P* values were calculated throughout this study.

2.3. Laboratory examination specific to the hen cohort

Parasitological examinations were performed at the Yeerongpilly Veterinary Laboratory (Queensland Department of Primary Industries, Yeerongpilly 4105) on fresh faeces using methods previously described for sugar flotation to detect coccidial oocysts, cryptosporidial cysts and helminth eggs (Anderson, 1981), quantitative egg counting (Roberts and O'Sullivan, 1950), and larval culture (Whitlock, 1948). Identification of the infective larvae of *Libyostrongylus douglassi* was undertaken as described by Barton and Seward (1993). Samples were collected on a single occasion from all pens containing hens enrolled within the hen cohort at any time during the months of July, August and September 1993. These pen results were considered to reflect the status of all hens held in the pen at that time. On one study farm, fresh faecal samples were also collected on a single occasion from three dogs and examined for *Trichuris* spp. using the sugar flotation method.

2.4. Data collection, management and analysis specific to the hen cohort

The information that was collected for each cohort hen included: date(s) of entry into and exit from the cohort, age (date of hatch or producer's best estimate), whether the hen had laid eggs (and whether these had subsequently hatched) at any stage prior to first entering the cohort, date of entry into and exit from a breeding group, identification and age (date of hatch or producer's best estimate) of cock(s) within a breeding group, and configuration of the breeding group (that is, a pair (one cock, one hen), trio (one cock, two hens) or colony (two cocks, two hens)). A breeding group was considered to comprise all the hens and cocks simultaneously held together within the same pen for breeding purposes.

Descriptive statistics and a test for normality were performed. Key production parameters were calculated to describe the performance of these birds. Because most parameters were not normally distributed, the 25th, 50th (median), 75th, and 90th percentiles were generally used as summary statistics to describe their distribution.

Because it was not possible to determine with confidence the parentage of eggs laid in pens holding a breeding trio or colony, measures of hen productivity were only calculated for 33 hens that were never held in these circumstances. Hen productivity, in terms of egg production, was measured in two ways. The number of eggs laid per hen per year was calculated for the 14 hens that remained within the cohort for 12 months. Because many hens remained within the hen cohort for less than 365 days (thereby making the previous parameter an inappropriate measure of hen performance), a hen productivity index was devised to enable an assessment of the egg-laying performance of all hens in the study. The index was determined after taking account of the period that the hen remained enrolled within the cohort, with adjustment being made for the number of eggs laid by (and therefore the distinctly seasonal egg output of) hens in the cohort during this period. The hen productivity index (for example, for hen A) was calculated as:

No. of eggs laid by hen A whilst within cohort

× (Total no. of eggs laid by all hens

/No. of eggs laid by all hens whilst hen A remained within cohort)

The relationships between age and productivity of hens were examined using the Wilcoxon rank-sum test.

The following calculations were also restricted to hens that were never held in trios or colonies whilst under observation. Fertility and hatchability percentages were calculated for 14 hens that laid more than 10 eggs whilst enrolled in the cohort. Data from 13 of these hens (those remaining with a single male and under observation for at least 9 months from 1 July 1993) were used to assess temporal patterns in egg laying by individual hens. Fertility was calculated as the percentage of incubated eggs that were fertile, and hatchability as the percentage of fertile eggs that hatched. Incubated eggs were considered fertile or otherwise based upon the findings by producers during candling. The goodness-of-fit of the Poisson distribution to data describing the laying interval between eggs was tested by chi-square to investigate the hypothesis that the eggs were laid randomly in time. A clutch was defined as either a single egg laid in isolation (that is separated by more than 2 days from other eggs laid by the same hen or a group of eggs laid at least each second day in an uninterrupted series by a single hen. The mean number of clutches, number of eggs within each clutch and the interval between clutches were calculated, whilst weighting for the total number of eggs laid by each hen during the period of interest.

A comparison of the time interval between study visits to the 12 study farms was examined using a one-way analysis of variance.

3. Results

3.1. Farm enrolment and visits

Brisbane is a coastal city located at 27°28″S, 153°02″E. The climate is subtropical with a predominantly summer rainfall pattern. The average annual rainfall is 1149 mm, and the average maximum and minimum temperatures are respectively 29°C and 21°C in January, and 20°C and 10°C in July.

In mid 1993, the A.O.A. (Queensland branch) was the only industry body representing ostrich producers in this region. Of the 80 members of this organisation, 45 (56%) had a mailing address within 100 km of Brisbane. Forty two of these members were contacted, and 18 had at least one pair of birds located within this region that were each over 18 months of age. Twelve producers were willing to participate of the study; the balance were not, either as a result of disinterest (1 producer), lack of time (1), concerns about confidentiality (1), or because the farm that incubated their eggs was unwilling to cooperate (3). On 30 June 1993, the 12 cooperating farms held an average of 2.8

Table 1
Percentage of some attributes of the producer, facilities and livestock on 12 ostrich farms in south-eastern Queensland during 1993/1994

	No. of farms	Percentage of farms
Producer [a]		
Prior commercial experience with poultry	1	8.3
Prior commercial experience with non-poultry livestock	9	75.0
Care of livestock on a full-time basis	7	58.3
Facilities		
Provision of shelter for breeding birds	8	66.7
On-site incubation	10	83.3
Provision of contract egg incubation service [b]	7	70.0
Routine fumigation of eggs	10	83.3
Livestock		
Other domestic poultry species on farm	10	83.3

[a] The person most directly associated with the care of the ostriches on each farm.
[b] Includes only those farms ($n = 10$) that used on-site egg incubation facilities during the study period.

(median 2, range 1–12) adult hens, representing 63% of all adult hens (of greater than 18 months of age) within the reference population. On the six farms whose producers were unwilling to participate in the study, there was an average of 3.2 (median 2, range 1–8) adult hens on this date.

Between June 1993 and July 1994, the 12 farms were visited at an average ($\pm$SD) of 44 ± 8 day intervals. There was no significant difference in the inter-visit interval between farms (one-way analysis of variance $F_{11,96} = 0.09$, $P = 0.999$).

3.2. Farm attributes

At the start of the study, half of the producers had been actively involved in the ostrich industry for 30 months or less (range 3–54 months). Nine of the producers had former experience with non-poultry livestock, but only one had previously worked commercially with poultry (Table 1). One person was committed on a full-time basis to the care of the ostriches on seven of the 12 farms.

An important financial commitment to facilities and livestock had been made on each of the 12 study farms, although these inputs were not quantified as part of this study. At the beginning of the study, 75% of the farms had three or less existing breeder pens (Table 2), although further pen construction was undertaken on nine of the 12 farms during the study. The size of the breeder pens varied greatly between farms (Table 2). Although not measured during the study, intra-farm pen variability was probably minimal because producers invariably constructed multiple breeder pens from a single basic design.

At the beginning of this study, on-site incubation was undertaken on ten of the 12 farms. On eight of these farms, the incubators had been constructed by three different manufacturers (LS Incubators Pty Ltd., Kingsgrove, N.S.W., two farms; Bellsouth Pty

Table 2
Distribution of some attributes of the producers, facilities and livestock on 12 ostrich farms in south-eastern Queensland during 1993/1994

	25th percentile	Median	75th percentile	90th percentile
Producer [a]				
Duration of active industry involvement prior to 1 July 1993 (months)	15.0	30.0	35.3	48.6
Facilities				
No. of breeding pens on 1 July 1993	1.0	2.5	3.0	10.3
Pen area (m^2) [b]	1804.5	2500.0	3476.3	17590.0
Length of longest straight pen boundary fence (m) [b]	50.0	81.5	100.0	141.0
Egg incubation capacity on 1 July 1993 [c]	22.0	61.5	120.0	120.0
Livestock				
Total no. of hen-years under observation	1.3	2.2	3.8	12.1
Cumulative number of hens enrolled into the hen cohort	2.3	3.0	6.3	18.2

[a] The person most directly associated with the care of the ostriches on each farm.
[b] At the first farm visit, measurements were taken of a single pen that was randomly selected from all pens that contained a single cohort hen.
[c] Includes only those farms ($n = 10$) that used on-site egg incubation facilities during the study period.

Ltd., Narre Warren, Vic., two farms; Multiquip Incubators, Austral, N.S.W., four farms), and home-made incubators were used on the two remaining farms. These farms had the capacity to simultaneously incubate between 12 and 120 eggs, with half of the farms having a capacity of 61 eggs or less. Three of these farms expanded their incubation capacity during the study period, and one farm commenced on-site incubation as the study concluded. Seven of the 10 farms that undertook on-farm incubation during the study period provided an egg-incubation service for other ostrich producers.

The number of ostriches on the 12 farms during the study period is shown in Fig. 1. These farms had a median of 3 (range 1–23) hens enrolled into the hen cohort during the study, providing a median of 2.2 (range 0.9–15.4) hen-years under observation. In addition to ostriches, 10 (83.3%) farms kept other domestic poultry species including domestic chickens, ducks, geese and peafowl.

3.3. Parasitological results

Fresh faecal samples were collected from pens containing 35 of the 36 different hens enrolled within the hen cohort during July to September 1993. The remaining hen could not be sampled prior to leaving the cohort. All samples were examined for nematode eggs and coccidial oocysts, and samples from pens holding four hens (11.4% of the sampled birds; with selection based upon convenience) were also examined for cryptosporidia.

Fourteen (40.0%) of the 35 hens were infected with *L. douglassi*, based on the results of larval culture. The maximum worm egg count for any positive sample was 200 eggs per gram (epg), and nematode eggs could only be detected using the faecal flotation and

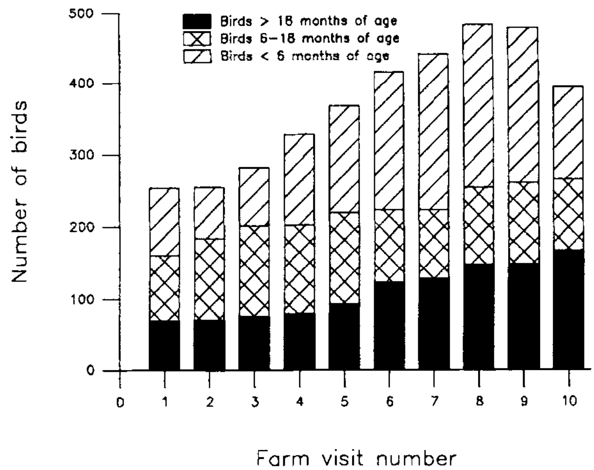

Fig. 1. The number of ostriches present on 12 farms in south-eastern Queensland during each of ten farm visits between June 1993 and July 1994. The farms were visited on average each 44 days during this 12 month period.

not the McMaster technique in culture-positive samples from six of these hens. A further four (11.4%) hens returned equivocal results to infestation with *L. douglassi* (that is, nematode eggs were detected using the McMaster and/or the faecal flotation technique, but no nematode larvae were observed following larval culture). If the equivocal results are considered false positive results (examination of further samples from pens containing two of these hens yielded negative results using each laboratory method), the hen prevalence for *L. douglassi* infection in this period was 40.0%, and the farm prevalence was 33.3%.

On one farm from which *L. douglassi* was cultured, large numbers (maximum 2250 epg) of nematode eggs resembling *Trichuris* spp. were also detected in faecal samples collected from all pens containing cohort hens. At a subsequent sampling 1 month later, similar nematode eggs could neither be detected in faeces collected from pens containing these hens nor in samples taken from three dogs that were kept in close contact with these birds. During the 6 months prior to the latter samplings, no anthelmintic treatment had been given by the producer to either the ostriches or the dogs.

Coccidial oocysts were not detected in any of the hen samples.

3.4. Hen performance

A total of 75 different breeding groups were formed during the year by 61 different hens and 51 different cocks. There were 56 pairs (providing 30.1 (73.2% of the total of 41.1) hen-years under observation), 16 trios (9.3 (22.6%) hen-years) and three colonies (1.7 (4.1%) hen-years). The cumulative number of hens enrolled during the study period is shown in Fig. 2. Twenty-nine breeding groups were already formed on 1 June 1993 and 13 were retained for 365 days. Thirty-six breeding groups (representing 47 cohort hens) were dissolved prior to 30 June 1994, with 33 hens later re-entering the hen cohort

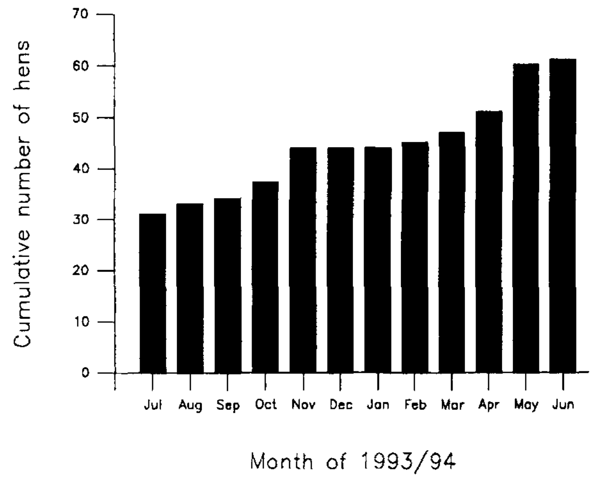

Fig. 2. The cumulative number of ostrich hens enrolled in the hen cohort on 12 farms in south-eastern Queensland during 1993/1994.

(79% of the 33 hens within one day of exit and 90% within 33 days of exit); two hens remained on a study farm but did not re-enter the cohort, and 12 left the study farm. The 75 breeding groups represented 100 cock/hen combinations (given that there are four cock/hen combinations in a colony, two within a trio and one within a pair). Within these breeding groups, the cocks were generally older than the hen(s), however, the difference in the age of the cock and hen within each cock/hen combination was not large (Table 3).

The 61 hens remained in the cohort for between 25 and 365 days, with half of the hens enrolled for less than 293 days. Twenty (33%) hens remained in the cohort for 365 days. The ages of these hens on 30 June 1994 ranged from 1.4 to 11.0 years (Table 3). Twenty-seven (44%) of the hens had laid at least one egg prior to first entering the hen cohort, but only 19 (31%) of the hens had previously laid eggs that hatched at least one live chick. No hens died whilst members of the hen cohort.

Producers ran 51 cocks with the cohort hens during the study period. The cumulative length of time that each cock ran with members of the hen cohort varied from 25 to 365 days, with a median of 283 days. The ages of these cocks on 30 June 1994 ranged from 1.5 to 11.0 years.

Nine hundred and ten eggs were laid by the hen cohort (816, 78 and 16 eggs in pens holding pairs, trios and colonies, respectively) between 1 July 1993 and 30 June 1994. Total monthly egg production was distinctly seasonal, with 84.1% of the eggs being laid in the months of August to and including March (Fig. 3). The hen productivity index, for 33 hens that were never held in a trio or colony, ranged from 0 to 90 (median 0), with 18 (54.3%) hens laying no eggs at all. Twenty-four of these hens remained in the cohort for more than 6 months, and there was a significant difference in the ages of those that achieved a productivity index of less than 10 (10 hens with a median age of 2.3 years) and those that achieved more that this (14 hens with a median age of 4.0 years) (Wilcoxon rank-sum statistic 13.7, $P < 0.001$).

Table 3
Distribution of some attributes and measures of productivity of 61 ostrich hens and 75 breeding groups on 12 farms in south-eastern Queensland during 1993/1994

Outcome	25th percentile	Median	75th percentile	90th percentile
Hen attributes				
Age of hens (age in years on 30 June 1994)	2.1	2.7	4.0	5.0
Age of cocks penned with cohort hen(s) (age in years on 30 June 1994) [a]	2.4	3.2	4.7	5.5
Cumulative length of enrolment in hen cohort (days)	98.0	293.0	365.0	365.0
Breeding-group attributes				
Length of formation (days)	57.0	150.0	296.0	365.0
Difference between the age of the cock and the hen within each cock:hen combination (age in years) [b]	0.0	0.1	1.3	4.1
Hen productivity [c]				
No. of eggs laid by enrolled hens during 1993/1994 [d]	0.0	31.0	82.7	90.0
Hen productivity index [e]	0.0	0.0	33.0	83.8
Fertility (%) [f]	58.4	70.0	88.2	93.4
Hatchability (%) [f]	57.1	67.7	80.1	88.5

[a] Includes the 55 ostrich cocks that were held with at least one of the cohort hens during the study period.
[b] A positive difference indicates that the cock was older than the hen.
[c] Measures of hen productivity were calculated for at most 33 hens that were never held in a trio or colony during the study period.
[d] Includes 14 hens that remained within the cohort for 365 days.
[e] Includes all 33 hens; see Section 2 for details.
[f] Includes 14 hens that laid more than ten eggs during the study.

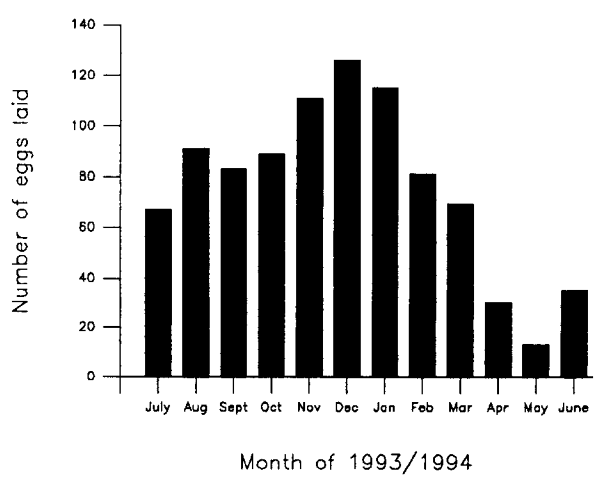

Fig. 3. The total number of eggs laid each month by hens under observation on 12 ostrich farms in south-eastern Queensland during 1993/1994.

Of the 33 hens never held in a trio or colony, 14 laid at least 10 eggs. These hens achieved a median fertility and hatchability of 70.0% (range 0–95.7%) and 67.7% (42.6–91.0%). The interval between eggs laid by 13 of these hens during the 9 month period from 1 July 1993 was not distributed randomly ($P < 0.001$ for each hen), but rather was clustered in time (variance exceeded the mean for each hen). Indeed, half of these eggs were laid within 2 days of a previously laid egg (median laying interval between eggs was 2 days, range 1–76 days). The hens laid an average of 9.1 (median 8, range 1–22) clutches containing an average of 3.5 (1, 1–22) eggs per clutch. The mean interval between clutches was 9.4 (6, 3–76) days.

4. Discussion

A study of this type would be of most value if the results closely reflected the health and productivity being attained by the whole Australian farmed ostrich population. Although the sampling for this work was necessarily one of convenience (that is, enrolment of farms was not random but was dependent upon producers' willingness to participate for 18 months), in terms of adult hen numbers, the farms in this study were similar to other eligible farms whose producers were unwilling to participate. The study farms also held 63% of all hens of breeding age within the reference population at the beginning of the study period. For these reasons, the study results might validly be generalised to the reference population. Anecdotal evidence from producers within the reference population—but not represented in this study—supports this view. It is not possible, however, to extrapolate the results of this work with confidence to other regions of Australia, nor to farms managed by more experienced ostrich producers.

Throughout this study, considerable reliance was placed upon the records kept and observations made by participating producers. Although this study would not have been possible without such assistance, it does raise questions as to the quality of the data that was collected and of the subsequent results that were obtained. A number of the producers were reluctant to keep detailed records. Consequently—and despite further data collection by the investigator at each farm visit—some data were incomplete. Steps were taken to minimise problems with data validity. Farms were visited frequently to allow verification of data recorded and/or recalled by producers. On three occasions during the study period, up-to-date and detailed summary reports were written and distributed to participating producers to provide them with some tangible benefit for their input, and to encourage producers to feel some ownership towards the data.

All producers were prepared to record key on-farm events including dates of lay, set, hatch and chick exit. However, every producer was reluctant to record events relating to disease and treatment—a difficulty that has also been noted previously (McDermott et al., 1991). This reluctance may reflect the extra commitment (particularly of time) that would be needed to complete a task not normally undertaken during daily farm activities. It is also possible that those producers who were experiencing problems with aspects of livestock production may have considered such data as somewhat self incriminating.

The farmed ostrich industry in south-eastern Queensland is young and growing rapidly. This activity was clearly evident on the 12 study farms in 1993/1994 where there was a steadily increasing number of birds of greater than 18 months of age, continued enrolment of new hens into the hen cohort throughout the study period, a short collective level of producer experience in the industry, continued pen construction on most farms and a low median age for both the cohort hens and the cocks held with these hens. Furthermore, of the 42 A.O.A. (Queensland branch) members contacted as part of this study in mid-1993, 14 (33%) did not own or manage a cock and/or hen of greater than 18 months of age.

The overall performance of the ostrich hens (measured in terms of egg production) was very disappointing, and a considerable cause of concern for most of the producers in this study. Although there were some exceptions, most hens laid very poorly. Much of this problem can be attributed to hen immaturity. Half of the hens on these study farms were still less than 2.7 years old at the end of the study period. Black (1995) suggested that full sexual maturity may not be reached in hens and cocks until 36 months and 48 months, respectively.

The hen productivity index was devised to allow comparison of the egg-laying performance of paired hens in the study, whilst adjusting for the distinctly seasonal output of eggs by this population, and the varying period that hens remained enrolled within the cohort. A simpler and more logical measure of productivity—the number of eggs laid per hen per year—was not applicable to this work because many hens did not remain under observation for the full 12 months of the study, although it is probably the measure most appropriate for industry adoption. The productivity index was only calculated for 33 hens (those held exclusively in pairs whilst under observation) because I could not determine with confidence the parentage of eggs laid in pens holding trios and colonies. Note that the summary measures of this index over-estimate the performance of the full cohort because hens held in trios and colonies were on average less-productive (laying 94 (10.3%) eggs during 11.0 (26.7%) hen-years of observation) than paired hens. For the 14 (42.4%) paired hens that remained within the cohort for the full study period, the hen productivity index is analogous to the number of eggs laid per year. However, this measure over-represents the true productivity of those hens (enrolled within the cohort for less than 365 days) that did not closely follow the seasonal pattern of egg production adopted by the wider population. It also over-represents the productivity of the hens that left the cohort to later re-enter, given that there was missing information during their absence. The over-estimate of productivity in the latter circumstance is slight, however, since most hens re-enrolled in the cohort within one day of exiting, and no eggs were laid during the study period by any hens in transition between periods of cohort enrolment.

As a result of the close confinement of birds in breeding pens, the regular coprophagic activity of this species, and the resilience of the infective third-stage larvae of *L. douglassi* under harsh climatic conditions (Barton and Seward, 1993), it is reasonable to assume that, if present, this parasite would rapidly infect all members of a breeding group. Faecal samples were collected from each breeding pen only once during this study because there is no published evidence of any seasonal variation in parasite counts. The farm prevalence for *L. douglassi* was similar to that obtained recently in southern Australia (Button et al., 1993). This is not surprising, given the considerable movement of birds into Queensland from southern Australian states (including Victoria), and the near universal lack of effective endoparasite control measures (quarantine facilities and/or routine prophylactic treatment for newly purchased birds) on the farms under observation. As with the Victorian study, faecal egg counts were very low. The absence of *L. douglassi* in chicks is a reflection of the common husbandry practice in Australia of raising chicks separately from adult birds. The presence of *Trichuris* spp.-like eggs in faecal samples from one farm was probably the result of coprophagia of fox faeces. Whipworm infestation was not found in any of the dogs associated with these birds, and fox activity in this area was common. It is surprising, given the importance of coccidia in other avian species, that these organisms were not identified in any of the samples taken from chicks or adult birds. Several protozoan species, including coccidia and *Histomonas meleagridis*, have previously been described in ostriches (Jensen et al., 1992, pp. 67–68). Cryptosporidia were not identified in faeces from any adult birds in this study, however, these results are difficult to interpret given the non-random selection of birds for sampling.

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