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ABSTRACT

The aim of this paper is to evaluate the effects of the age of ostriches and month of laying on egg production and chick growth. On a small ostrich farm egg production, egg incubation and chick growth from hatching to 56 days of age were recorded from 2000, when the breeders were 5 years old, until 2002. Ostriches were kept in groups and fed commercial feed. In all, 568 eggs were laid and weighed at laying and during incubation (at 15th and 30th day of incubation), while 353 chicks were weighed at hatching, 7, 14, 28 and 56 days of age.

The female's productivity was calculated assuming a laying of 3.5 eggs per week and ranged between 45% and 48%. The fertility was around 70% with a peak of 74% recorded in 2001. The hatchability of all eggs was higher than 62% with a peak of 72% in 2001, while the hatchability of fertile eggs was higher than 90%. In each year the number of eggs laid increased from March to July, productivity showed a positive trend from May to June, while the fertility and hatchability of all eggs, as well as fertile eggs, was unaffected by year and month. As the hens aged, the egg mass grew constantly with an increase of about 8%. During the first 30 days of incubation the egg weight decreased with the percentages of weight loss around 10.0%. At hatching, the weight of chick ranged between 765 g and 847 g, respectively, in 2000 and 2002. Egg weight influenced the hatching weight showing a linear relationship (R^2=0.84). The effect of egg weight on the chick weight decreased as the chick grew. At 56 days of age, only the effect of year is significant. The month of laying did not demonstrate any effect on chicken weight.

Key words: Ostrich (*Struthio camelus*), Reproductive traits, Egg weight, Chick growth.

RIASSUNTO

L'EFFETTO DEL PESO DELL'UOVO SUL PESO E SULLA CRESCITA DEL PULCINO DI STRUZZO *(STRUTHIO CAMELUS)*

L'obiettivo del lavoro è stato di valutare l'effetto dell'età della femmina di struzzo e del mese di deposizione sulla produzione di uova e sull'accrescimento del pulcino. In un piccolo allevamento, nel periodo compresso tra il 2000, quando le femmine avevano 5 anni, ed il 2002 sono stati registrati i dati relativi alla produzione e all'incubazione delle uova nonché alla crescita del pulcino dalla schiusa fino a 56 giorni di età. Gli struzzi sono stati mantenuti in gruppo e alimentati con mangimi commerciali. In tutto 568 uova sono state registrate e pesate al momento della deposizione e durante l'incubazione (al 15° ed al 30° giorno), mentre 353 pulcini sono stati pesati al momento della schiusa, a 7, 14, 28 e 56 giorni di età.

La produttività, calcolata assumendo una deposizione di 3,5 uova per settimana, è oscillata tra il 45% e il 48%. La fertilità è stata di circa il 70% con un picco del 74% nel corso del 2001. La percentuale di schiusa di tutte le uova incubate è stata superiore al 62% con un valore massimo intorno al 72% nel 2001, mentre quella delle uova fecondate è stata

superiore al 90%. Ogni anno il numero di uova deposte ha evidenziato un andamento positivo tra Marzo e Luglio, la produttività ha mostrato un trend positivo a partire dal mese di Aprile al mese di Giugno, mentre la fertilità e la schiusa, sia di tutte le uova sia delle sole fecondate, non sono state influenzate né dall'anno né dal mese di deposizione. Con l'invecchiare delle femmine, dal 2000 al 2002, la massa dell'uovo è aumentata progressivamente di circa l'8%. La percentuale della perdita di peso durante l'incubazione è stata costante, circa il 10% (al 30° giorno), e non è risultata influenzata né dall'anno di deposizione né dal peso del uovo. Il peso dell'uovo ha influenzato il peso del pulcino alla schiusa, mostrando una relazione lineare (R^2=0.84). In seguito, con la crescita del pulcino, l'effetto del peso dell'uovo è venuto meno. A 56 giorni di età, i pulcini mostrano differenze di peso significative, ma solo relativamente all'anno di deposizione delle uova, mentre nessuna differenza è imputabile al mese di deposizione.

Parole chiave: *Struzzo (Struthio camelus), Prestazioni riproduttive, Peso dell'uovo, Crescita del pulcino*

Introduction

In Italy ostrich farming can be considered a new entry of animal production. Modern ostrich farming started only after 1990 (Endrighi *et al.*, 1997) although earlier attempts at breeding were reported in the years 1900-1920 (Faelli, 1939). The most recent available data indicate the existence of 1,425 farms in Italy, of which more than 56% are small flocks where less than 10 birds are kept. Totally about 40,000 ostriches are reared and more than 52% are farmed in a few relatively large farms with more than 100 birds (ISTAT, 2000). In recent years, due to the need to diversify animal production and the BSE crisis, interest in ostriches has been increasing not only for high quality leather, but also for meat production. However, as also observed in other countries (Deeming, 1996), the scientific data obtained in loco are limited; therefore, producers are forced to use information obtained in different countries where the climatic and environmental conditions could be very different from their own situation.

Endrighi *et al.*, (1997) reported that the most frequent problems faced by Italian ostrich producers were due to inadequate breeding practices, especially regarding the reproductive aspects. Increasing commercial interest requires more information about ostrich reproductive ability. Castrovilli *et al.* (2000) report that in northern Italy the laying season ranged between February/March and September, although a small number of eggs can be laid during the winter season; while Nizza (2002) and Di Meo *et al.* (2003) observed in southern Italy the laying season could start in January. The peak of the laying season is recorded from May to July. Similar results were reported in other European countries (Deeming, 1996; Horbañczuk and Sales, 2001). Nevertheless, in northern Italy some Italian producers prefer to stop the laying at the beginning of August in order to avoid raising chicks in the autumn when rainfall increases.

The goal of this study is to evaluate the effect of age of hens and month of laying on ostrich egg productivity, fertility, hatchability and chick growth until 56 days of age in a small flock located in northern Italy.

Material and methods

The data recorded are relative to a three-year production period (from 2000 to 2002) in a Blue neck ostrich flock located in the center of the Piedmont region. Only the eggs laid from March to July were considered because in February laying season is just beginning and few eggs were laid, while in August egg laying is stopped by the farmer applying a one-week starvation to the breeder at the beginning of the month.

In the first year the flock consisted of 6 female and 6 male breeders followed during the three years. In 2000, the farm had 6 cocks at 5 years old and 6 hens of the same age divided into groups (3 males/3 females per group); in 2001, one male died and a minor adjustment was made to the group (i.e. one group 3 males/4 females, one group 2 males/2 females); in 2002 the number of males was reduced again and two groups of 5 birds (2 males/3 females) were arranged.

Each group was kept in one pen of 4000 m^2 containing a roof of 30 m^2 equipped with drinking water, feeding-trough and a sandy zone for nesting. During the three laying seasons, ostriches received the same diet: *ad libitum* lucerne hay and 2 kg of a commercial pelletized breeder diet per day. The commercial diet (containing soybean, corn, dehydrated alfalfa, sunflower, carob meals and wheat middling) supplied about 190 g crude protein, 120 g crude fiber per kg of dry matter (87.5%), 22 g calcium and 9 g phosphorus. Ostriches were fed twice a day.

Eggs were collected twice a day at 18:00 and 20:00, respectively, and the collection date of each egg was recorded. After collection, eggs were cleaned using a dry cloth and sanitized by hand washing with Virkon solution (Antec International). Once the eggshells were dried the eggs were marked with permanent pencil. Moreover, all eggs were individually weighed and then stored at 17°C. Before incubation, eggs were candled in order to remove eggs with eggshell defects. Every Friday, eggs were incubated in a multi-stage incubator (Victoria I-18) set at 36.2 °C and relative humidity (RH) of 25%. Eggs were candled and weighed at the 15th and 30th day of incubation in order to remove the unfertilized and undeveloped eggs. On the 39th day eggs were moved to a Victoria H-3 hatcher set at 35.6 °C with a RH of about 60% and the chicks were hatched.

At 36 h after hatching the chicks were moved into an indoor brooding area with an initial temperature of 32-33 °C, which was reduced by 2 °C per day until it reached 23-24 °C. To prevent impaction, the floor of the brooding area was fitted with felt carpet that was replaced every second day. After yolk sack retraction, chicks were fed a commercial chick diet giving 250 g crude protein and 120 g crude fiber per kg of dry matter. Two weeks after hatching, the commercial diet was supplemented with ground yellow corn grain and alfalfa hay. At 21 days chicks were allowed into an outdoor pen. The feed, containing 210 g crude protein and 160 g crude fiber per kg of dry matter, was supplemented with ground yellow corn grain and alfalfa hay to satiety. Drinking water was available at all times. Chicks were weighed at hatching, 7, 14, 28 and 56 days of age. In order to match the egg to the chick, the hatcher basket was divided into single cells; when transferring chicks to the brooding area the same number identifying the egg was marked in permanent ink on a Velcro tape fixed to the bird's leg.

The dataset was evaluated by ANOVA and significant differences were determined by the Tukey test (SPSS, 1999a); moreover the relationship between egg weight and chick weight was analyzed using a multiple regression model (SPSS, 1999b).

Results

Egg production during the years

The egg production from March to July was analyzed. In 2000, egg laying from March to July lasted 18 weeks, while in 2001 and 2002, due to an early start of laying, it lasted 20 weeks, respectively. The relative parameters are reported in Table 1.

In all, 568 eggs were recorded. Although the length of laying season was shorter in 2000 than in 2001 and 2002, the productivity appears similar among the years, in particular when comparing 2000 with 2002.

In 2002 the total number of eggs laid decreased compared to 2001. The productivity, cal-

Table 1. Statistics of eggs laid according to the different years.

Year (age of hens)		2000 (5)	2001 (6)	2002 (7)
Weeks of laying	n.	18	20	20
Total eggs laid	"	174	203	191
Productivity	%	46.03	48.33	45.47
Fertility	"	66.09	74.38	64.92
Hatchability of all eggs	"	62.06	72.41	62.83
Hatchability of fertile eggs	"	93.91	97.35	96.77

Table 2. Statistics of eggs laid according to the different months.

Month		March			April			May			June			July		
Year		2000	2001	2002	2000	2001	2002	2000	2001	2002	2000	2001	2002	2000	2001	2002
Total eggs laid	n.	22	15	18	26	30	31	38	42	45	43	57	54	45	59	43
Egg productivity	%	34.9	35.7	42.8	31.0	35.7	36.9	45.2	50.0	53.5	51.2	67.8	64.3	53.6	70.2	51.2
Fertility	"	90.9	73.3	61.1	65.4	66.7	67.7	73.7	66.7	55.5	65.1	80.7	64.8	48.9	77.9	74.4
Hatchability of all eggs	"	81.8	66.7	55.6	65.4	63.3	64.5	71.1	66.7	55.5	60.5	78.9	63.0	44.4	76.3	72.1
Hatchability of fertile eggs	"	90.0	90.9	90.9	100	95.0	95.2	96.4	100	100	92.9	97.8	97.1	90.9	97.8	96.8

culated assuming a laying of 3.5 eggs per week (Deeming, 1996) ranged from 45.47% to 48.33%. The fertility and hatchability ranged from 64.92% to 74.38% and from 62.06% to 72.41%, respectively. Table 2 shows egg production parameters analyzed according to month of laying.

The number of eggs laid increased steadily from March to July, except for those of July in 2002. Conversely, productivity in all the years shows an initial decrease from March to April followed by an increase until the end of laying. The cumulative egg production recorded in June and July was always equal to or more than 50% of seasonal egg production recorded in all the years; this fact was evident also in 2002, even if a reduction of eggs laid was observed in July. Irrespective of the years and months, the fertility and hatchability of all eggs ranged from 48.9% to 90.9% and from 44.4% to 81.8%, respectively. The hatchability of fertile eggs was always good, reaching a value higher than 90% and in some cases 100%.

The change of egg weight during hatching

The data in Table 3 show a progressive increase of 8.3% of egg weight at laying from 2000 to 2002.

The significant difference (P≤0.05) was observed between egg weight laid in 2000 and those in 2001 and 2002. Weight loss during the first 30 days of incubation was not affected by the initial weight of the eggs; in fact, the percentage of weight loss was the same in all three years.

Moreover, the egg weight had been evaluated in relation to the month of laying.

Results are shown in Figure 1. In 2000 egg weight at laying was always significantly (P≤0.05) different among the months, showing the highest value in April.

Conversely, in 2001 the egg weight of March was significantly lower than the other months. There were no significant differences among the months in 2002.

The weight at the 15th day and 30th day of incubation showed a similar trend with weight at laying and the same statistical differences were shown. The result is due to the fact that the weight loss percentages are constant throughout the years: 9.86; 9.87 and 10.07 for year 2000, 2001 and 2002, respectively.

The change of chick weight during first 56 days of life

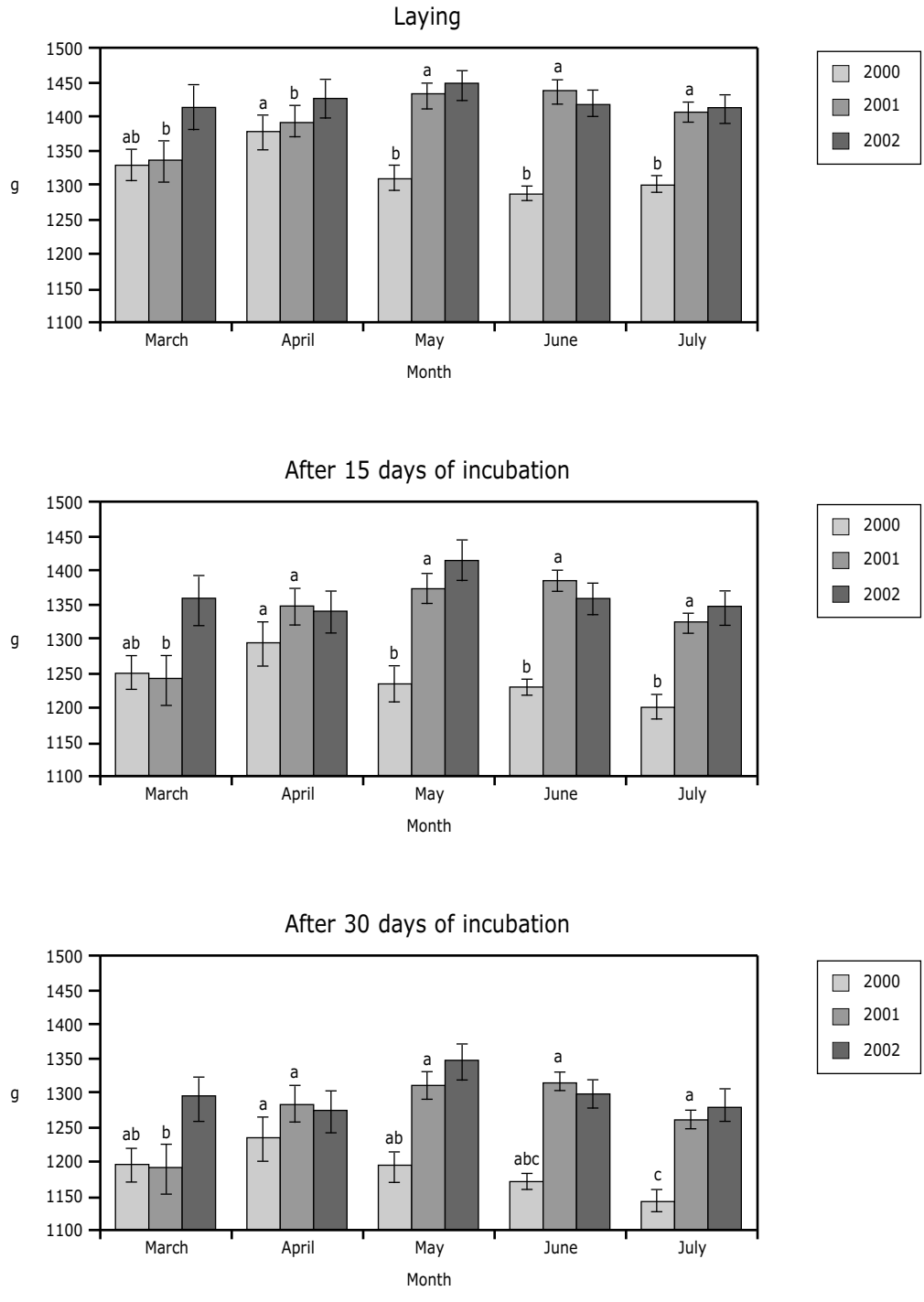
The weights recorded for chick growth from hatching to 56 days of age are reported in Table 4.

Table 3. Egg weight (mean ± SE) at laying, during the incubation and weight loss (± SE) according to the different years.

Year (age of hens)		2000 (5)	2001 (6)	2002 (7)
Laying	g	1316.32±7.57b	1413.40±8.31a	1425.24±9.84a
15 days	"	1238.26±9.74b	1347.95±8.65a	1361.29±12.26a
30 days	"	1181.93±9.11b	1283.29±8.28a	1296.45±11.64a
Weight loss	%	9.86±0.11	9.87±0.23	10.07±0.09

Different letters in same row indicate significant differences (P≤0.05)

Figure 1. Trend of egg weight (mean ± SE) from laying to 30th day of incubation.



Different letter, at the same year, indicates differences among months (P≤0.05)

Table 4. Chick weight (mean ± SE) at different ages and survival at 56 days of age by year.

Year		2000	2001	2002
Chicks	n.	97	143	113
Hatching	g	765.74±5.28b	833.47±6.28a	847.83±7.11a
7 days	"	793.52±5.64c	857.40±5.99b	875.47±6.90a
14 days	"	1063.40±6.48c	1079.51±4.15b	1096.52±4.90a
28 days	"	3552.86±22.09c	3653.99±26.36b	3728.14±28.09a
56 days	"	10729.69±80.72b	10863.64±95.89ab	11046.90±50.05a
Survival	%	89.8	97.3	94.2

Different letters in same row indicate significant differences (P ≤ 0.05)

In all, 353 chicks were hatched during the three years. At hatching the chick weight showed significant differences, chicks hatched in 2001 and 2002 were heavier than chicks hatched in 2000, while no difference was observed between those hatched in 2001 and 2002. At 56 days of age significant differences were observed: chicks hatched in 2000 were significantly lighter than those hatched in 2002, while no difference appears for chicks hatched in 2001 compared to those hatched in 2000 and 2002. The overall mean weekly weight gain recorded in 8 weeks ranged from 1245.49 g to 1380.86 g in 2000 and 2002, respectively. The survival rate during the first 56 days of life was rather high ranging from 89.8% to 97.3%

The chick growth was also evaluated according to the month of laying and the data obtained are shown in Figure 2.

According to the trend of egg weight, the chick weight at hatching appeared affected by the year but not by the month of laying. In 2000, the month showed a short significant effect (P≤0.05) for the weight at hatching (798.82 g *vs* 733.50 g) and after 7 days (831.18 g *vs* 758.42 g) relative to the eggs laid in April and July, respectively, but this difference disappeared after 14 days. In 2001, the differences at hatching weight were the same as egg weight at laying. Chicks hatched from eggs laid in March were significantly lighter than the others and the difference disappeared when chicks reached the age of 56 days. In 2002, in spite of the lack of statistical difference for egg weight at laying, chicks hatched from eggs laid in May were statistically heavier than those hatched from eggs laid in March, April and July. As observed in 2000, the difference disappeared after 14 days. In all the years, no differences due to the month of laying were observed for the survival rate.

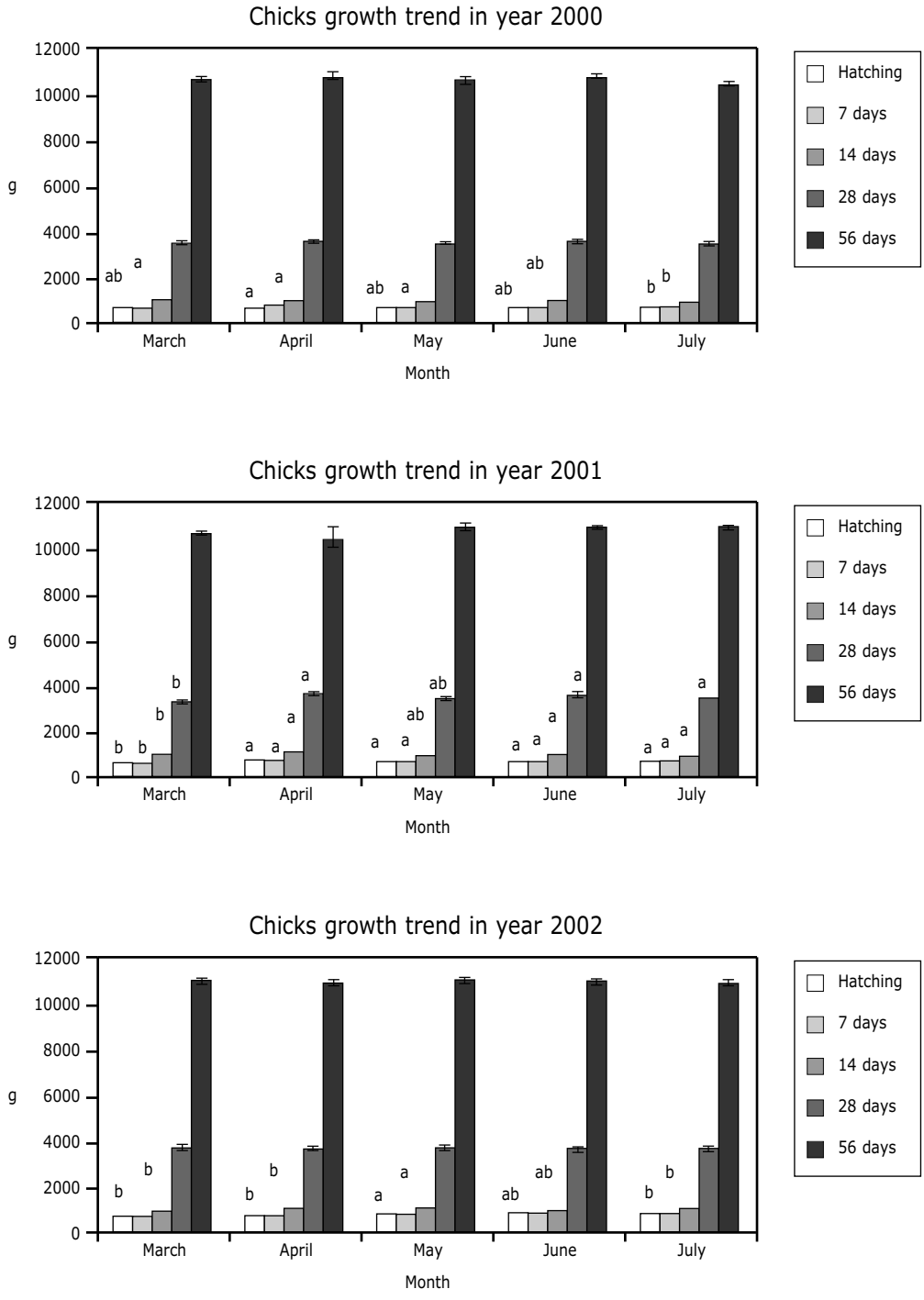
The relationship between egg weight and chick weight at hatching

The results concerning the relationships existing between the egg weight and the chick weight at hatching are reported in Table 5 and Figure 3. Different models of regression have been evaluated and, excluding the cubic model, all of them are statistically significant. The weight of chicks can be easily estimated using a linear model (R^2=0.84).

Table 5. Parameters of regression models (384 observations).

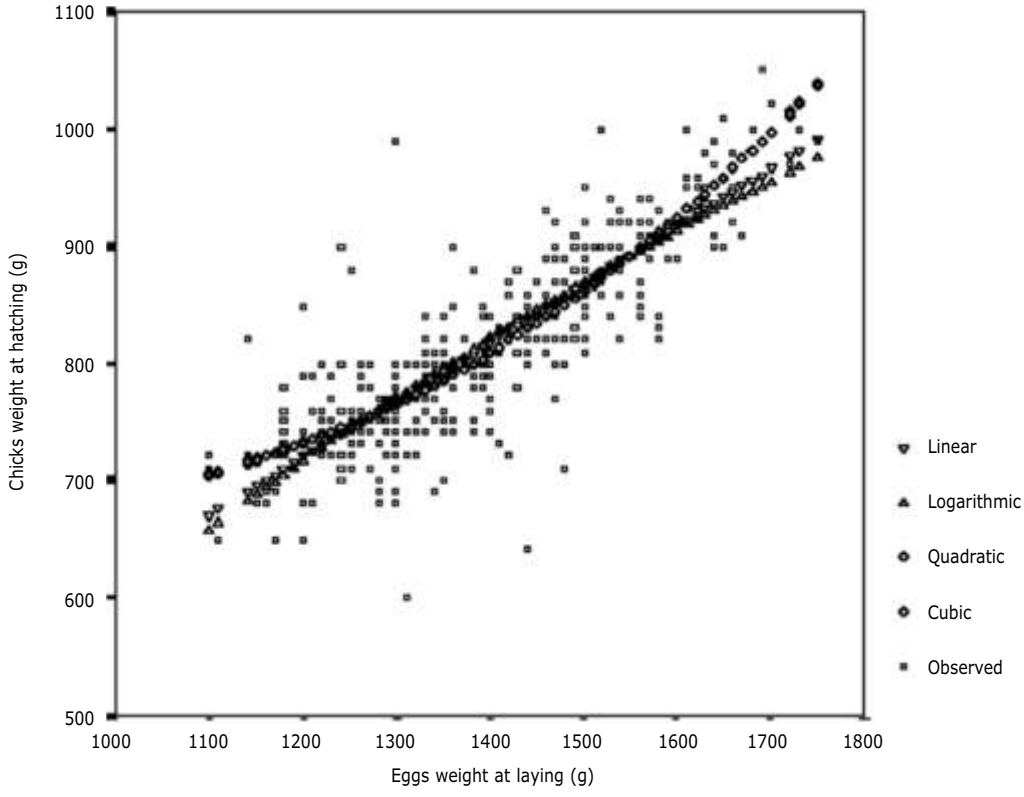
	a	b	c	d	R^2	P≤
Linear	126.06	0.494	-	-	0.84	0.001
Logarithmic	-4143.52	685.42	-	-	0.83	0.001
Quadratic	1055.91	-0.835	0.00047	-	0.85	0.03
Cubic	741.00	-0.166	14.15	0.0000001	0.85	0.24

Figure 2. Chick weight (mean ± SE) at different ages by month.



Different letter, at the same age, indicates differences among months ($p \leq 0.05$)

Figure 3. Relation between egg weight and chick weight.



Discussion

The influence of breeder on egg laying and productivity

There was a notable increase of egg production parameters (including number of eggs laid, productivity, fertility and hatchability) from 2000 to 2001 and a decrease from 2001 to 2002. The increase of production is probably due to age of breeder. In 2000, both the male and female were 5 years old and in 2001 they are 6 years old. The results of productivity, fertility and hatchability agreed with the results of Deeming (1996) and can confirm that ostriches reach good reproductive ability at 5-6 years old. The group arrangement of 3 males/4 females could guarantee the reproductive parameters and males could be reduced to some extent.

The reproductive parameters

In the Italian climatic situation, the mean number of eggs laid per female is reported ranging from a minimum of 27 (Castrovilli *et al.*, 2000) to a maximum of 65 (Nizza, 2002). In this report, the average number of eggs laid per female, reared in groups, is 28 from March to July that is similar to the results of Castrovilli *et al.* (2000).

In this report the productivity values ranged from 45.47% to 48.33 %, which fell in the ranges indicated by Deeming (1996) and are in agreement with those reported by Di Meo *et al.* (2003). Concerning fertility Nizza (2002) reported 62% to 75% and 49% to 57% for hatchability. Similar percentages of fertility were observed in experimental conditions by Schiavone *et al.* (2000) reporting a mean value of 70% for fertility and 60% for hatchability. Our results showed fertility ranged

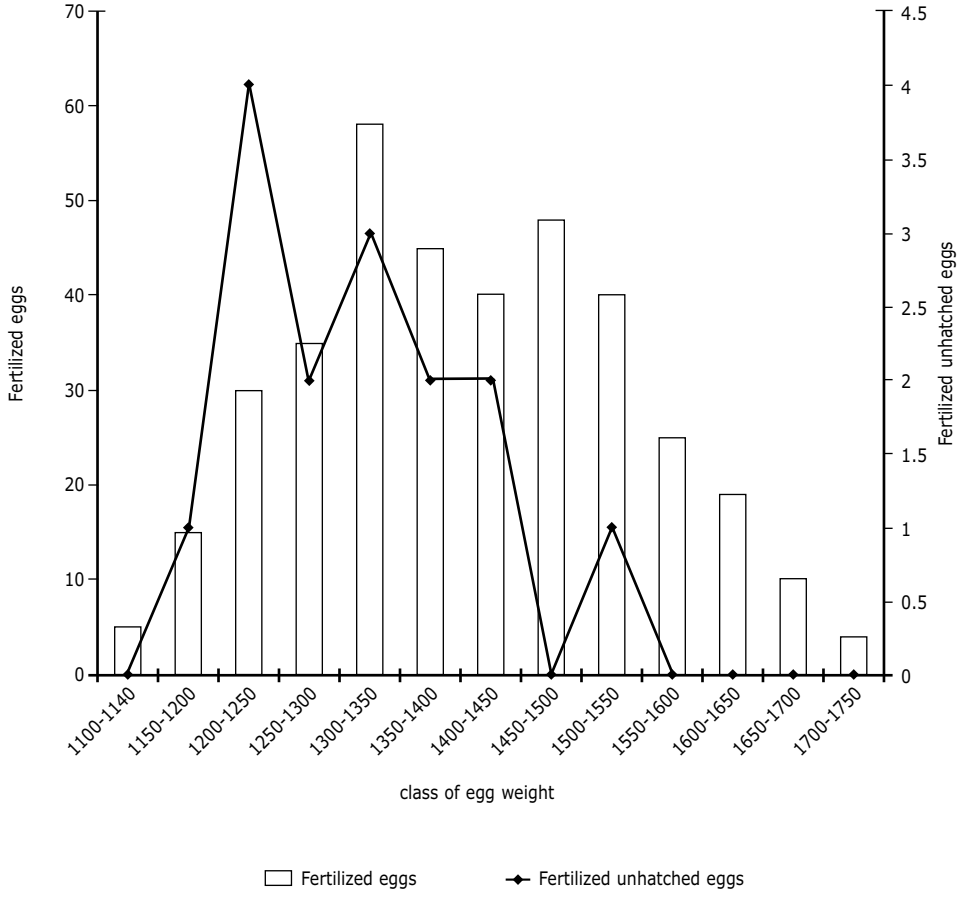
from 64.92% to 74.38% and from 62.06% to 72.41% for hatchability. These results show good fertility and high hatchability compared with the results of Deeming (1995; 1996) and Horbañczuk *et al.* (1999). Regarding the survival rate, we obtained a high percentage - around 90% - in the first two months; this data is higher than that reported by More (1996) which indicated survival of 72%. However, the data were obtained under different climatic conditions.

Effect of egg weight on hatching weight and growth rate

Egg weight is an important factor that influences hatching weight and growth rate. First of all, greater ostrich egg weight can lead to higher hatchability of all eggs and fertile eggs, which can be reflected either by the years from 2000 to 2002 or by the months from March to July.

The relationship between egg and hatching weight is well established in avian species (Bell and Weaver, 2002). This relationship can affect later body weight in chicken production. At hatching, ostrich chick weight represents around 58-59% of the egg weight at laying; this value results slightly lower than the 62.3% observed by More (1996). Our results showed that ostrich egg weight can be described as a positive linear relationship

Figure 4. The number of fertilized eggs and fertilized but unhatched eggs for different egg weight.



with hatching weight, while no relationship has been observed for body weight at 56 days.

The weight loss of eggs observed during the first 30 days of incubation ranged around 10% and appears constant in the different years and months. For the first 30 days the weight loss is in agreement with observation of Schiavone *et al.* (2000) who recorded the weight loss until 39 days of incubation. As indicated by Horbañczuk *et al.* (1999), the role of relative humidity (RH) on weight loss is important. Our eggs were incubated at 25% RH. This level of humidity allowed a good control of weight loss. Horbañczuk (2000) indicated that the highest hatchability was reached when the egg weight ranged from 1200 to 1800g. Our data do not allow us to indicate an optimal range of egg weight because the number of fertilized but unhatched eggs is very few and randomly distributed in all weight classes. As reported in Figure 4 , subdividing the eggs into classes of 50 g, the highest number of fertilized eggs was recorded in the interval from 1300 g to 1350 g and the highest number of fertilized but unhatched eggs was recorded in the interval from 1200 to 1250 g. However, it seems that the heavier fertilized eggs would have the lowest unhatchable percentage, which confirms the indication of Horbañczuk (2000) in respect to the optimal weight of eggs.

The growth rate during the first week of life was lowest, due to the starvation applied by the producer till the complete retraction of the yolk sac. From this point of view, the hatching weight affected the chick weight until 7 days of life. This effect decreased as the days progressed. At 56 days of age, only the chicks hatched in 2002 showed higher weight than those hatched in 2000. The months in which eggs are laid initially affects the growth performance of chicks; however, after two weeks there is no longer a significant difference and the survival rate is not affected. This agreed with the phenomena observed in other animals (i.e. there will be a growth recovery when higher nutrition feedings are supplied followed by a short period of lower nutrition feedings (Patterson and Steen, 1995)). The hatching weight reported by Degen *et al.* (1991) results higher than that observed here, nevertheless, no difference appears as regards the growth rate within the first 56 days. Our data are in agreement with those reported by du Preez *et al.* (1992) and Mushi *et al.* (1998) who worked on Zimbabwean ostriches, but it is important to remember that the growth rate can be affected by different factors. In fact Anderloni (1995) reports lower weights for 56 day old chicks than those reported here.

Conclusions

In order to avoid chick growth during the unfavorable season, the farmer stops the laying season in the first week of August. Nevertheless, for eggs laid within 2000 and 2002, the productivity ranged from 45.47 to 48.33% while the fertility ranged from 64.92% to 74.38%. The overall hatchability ranged from 62.06% to 72.41% and hatchability of fertile eggs was about 90%.

The results of our limited observations confirm that the reproductive traits are affected by the age of the breeder and the management of grouping. Ostriches reach good reproductive ability at 6 years old and the group of 3 males/4 females can allow good production even if the rearrangement of group can induce a decrease of productivity.

From this point of view, it is important to highlight that the weight of eggs depends not only on age and size of hens, but also on many other factors such as genetics, management, sequence of laying, feeding and nutrition. During incubation the weight loss was constant among the years and this fact confirms good incubation practice. Moreover, the egg weight had a positive effect on the hatching weight and the significant relationship between them can be described by linear model. However, as chicks grew, the effect decreased. At the age of 56 days, the influence of egg weight on chick weight was not significant. There is a certain compensatory growth after hatching.

In conclusion, nevertheless the results obtained seem to confirm many similarities with the commercial poultry species, further research is needed in order to improve knowledge of determinant factors of reproductive traits in ostriches.

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