J. Reprod. Fert. (1972) **29**, 317–325

SEMEN CHARACTERISTICS OF TWO BREEDS OF TURKEYS

GAMAL A. R. KAMAR AND M. A. A. RIZIK

Animal Production Department, Faculty of Agriculture, Cairo University, Giza, Egypt

(*Received* 29*th June* 1970, *accepted* 13*th November* 1971)

Summary. Semen samples were collected from ten Bronze and ten Beltsville Small White turkeys by the massage method without milking the copulatory organ. The birds were kept under natural conditions at Giza, Egypt (lat. 30°N). Four collections were tested each month throughout 1 year. The collections of alternate weeks were used for studying the physical and chemical characteristics respectively. The largest volumes of semen were produced between March and October, and the smallest between November and February. The best semen quality was recorded between November and April, and the poorest between May and August. A sharp decline in all semen characteristics occurred during May. If the causes of this decline can be avoided, the time of obtaining best semen qualities is prolonged. The semen production of Beltsville Small White turkeys was better than that of the Bronze breed. Wide seasonal variations in types of sperm abnormality were observed.

Seminal fructose and vitamin C were high between November and April, and low from May to August. Semen quality was directly related to levels of seminal fructose and vitamin C. Slight seasonal and monthly variations were observed in inorganic phosphate levels. The rate of fructose metabolism by the spermatozoa was high during the first hour and decreased consistently thereafter. The large quantity of carbon dioxide produced during the first hour depressed sperm viability.

INTRODUCTION

Before mid-December, the semen volume produced by Broad Breasted Bronze and Bronze turkeys has been reported to be very small. The highest increase was observed between December and January, the values remaining constant thereafter, until a decrease occurred at the beginning of summer (Aslanjan, Soroke & Sinkarenko, 1963). Sperm motility is low until January after which it remains at a relatively high level until June, when a decrease occurs (Parker, 1946). The highest sperm concentrations were noted in the spring, and the lowest during the winter. Aslanjan *et al.* (1963) also observed low concentrations during summer and autumn. Complete cessation of semen production has been reported in the majority of males from August to November (Carson, Lorenz & Asmundson, 1955).

MATERIALS AND METHODS

Ten Bronze and ten Beltsville Small White turkeys which were 1 year old at the beginning of the experiment were available. The average body weight of the males of the two breeds were 17 and 12 kg, respectively. All the birds were managed alike and fed on a ration containing 15% maize, 13% wheat, 10% barley, 18% wheat bran, 15% rice bran, 5% broad beans, 23% cotton seed meal, 1·5% calcium carbonate and 0·5% salt. Fresh blood, skimmed milk and dried milk were supplied. Green feed was supplied as Egyptian clover in winter and chopped green maize leaves in summer.

Semen was collected by the massage method, without milking the copulatory organs (Kamar, 1958). Trials in which turkeys ejaculated at the first attempt were regarded as successful. Those males which failed to ejaculate were tested the following day and the trials in which semen was not obtained were regarded as unsuccessful. Ejaculatory responsiveness was measured by the percentage of successful trials. Semen volume (ml), motility (rating score—Kamar, 1960), concentration (spermatozoa/mm^3), percentage live spermatozoa (Kamar, 1959a), percentage abnormal spermatozoa (Kamar, 1959b), total number of spermatozoa, number of live spermatozoa, and number of abnormal spermatozoa/ejaculate were estimated by the methods previously used for fowl (*Gallus domesticus*).

Ascorbic acid was determined according to the method of Roe & Kuether (Hawk, Oser & Summerson, 1947). Phosphate was determined according to the method of Fiske & SubbaRow (Hawk *et al.*, 1947), while fructose concentration and CO_2 production were determined by the methods described by Mann (1948).

Semen collections were made once a week. The collection of one week was used to study the physical characteristics of the semen for each individual, while that of the following week was used to study the chemical characteristics of semen from all the males of the two breeds grouped together. Fructose was evaluated in the whole semen. Vitamin C and inorganic phosphate were evaluated in seminal plasma.

Analysis of variance was calculated for the various semen characteristics as affected by months, breeds and individuals (Snedecor, 1957).

RESULTS

Physical characteristics

'Semen quantity' was regarded as being represented by semen volume, sperm concentration and number of sperm produced, normal or abnormal, live or dead. 'Semen quality' was taken to refer to sperm motility, viability and morphology. The largest semen quantity was produced from March to October in both breeds (Table 1). Increase in semen quantity coincided with the long days of spring and summer and, when day-length decreased, the quantity also decreased.

The smallest semen quantities were produced from November to February in climates of low temperature, high relative humidity and short days.

The best semen quality was also observed under climates of low temperature, high relative humidity and short days from November to April. By contrast, the poorest semen quality was observed from May to August when sexual activity was high, air temperature was also high, days were long and the weather was dry.

The highest ejaculatory responsiveness as measured by successful trials coincided with the months of moderate and hot weather, long days and low relative humidity. During the winter, responsiveness was depressed.

TABLE 1

MONTHLY AND SEASONAL VARIATIONS IN SEMEN CHARACTERISTICS OF BRONZE AND BELTSVILLE SMALL WHITE TURKEYS

Month	*Successful trials* (%)		*Volume* (*ml*)		*Motility*		*% live sperm. in fresh semen*		*% total abnormal sperm.*		*Sperm conc.* $\times 10^6$/*mm*^{3}		*Sperm. per ejaculate* $\times 10^7$	
	B	*BW*	*B*	*BW*	*B*	*BW*	*B*	*BW*	*B*	*BW*	*B*	*BW*	*B*	*BW*
December	90	90	0·21	0·20	2·8	3·7	86·9	93·8	10·1	6·3	5·7	7·9	120	159
January	80	60	0·29	0·13	3·7	4·1	92·0	94·3	7·2	5·7	5·2	5·3	151	69
February	90	90	0·25	0·23	3·4	3·4	90·0	90·5	10·5	7·8	6·4	8·3	161	190
Winter	87	80	0·25	0·19	3·3	3·7	89·6	92·9	9·3	6·6	5·8	7·1	145	135
March	100	100	0·36	0·31	3·7	3·4	91·5	88·9	8·4	9·2	10·9	11·2	393	348
April	100	100	0·35	0·45	3·2	3·6	90·6	86·8	10·2	11·5	13·5	13·3	473	600
May	90	80	0·20	0·27	2·0	2·4	67·4	76·3	20·1	17·3	4·3	7·4	85	200
Spring	97	93	0·30	0·34	3·0	3·1	83·2	81·0	12·9	12·7	9·6	10·7	287	362
June	100	90	0·35	0·31	2·7	3·4	81·1	84·3	13·0	10·3	10·6	9·5	372	295
July	100	100	0·33	0·41	2·1	2·2	69·9	74·9	19·2	17·1	9·6	10·1	317	413
August	90	100	0·35	0·27	2·6	2·5	72·8	81·8	15·8	12·8	8·6	7·5	298	202
Summer	97	97	0·34	0·33	2·5	2·7	74·4	80·3	16·0	13·4	9·6	9·0	325	298
September	100	90	0·36	0·35	2·7	2·4	83·2	86·6	14·6	10·9	8·4	8·5	303	297
October	100	90	0·26	0·33	2·3	2·8	84·2	87·2	11·8	10·4	7·6	9·6	197	316
November	100	100	0·22	0·23	3·0	3·3	88·9	90·5	9·0	9·0	9·2	8·9	202	206
Autumn	100	93	0·28	0·30	2·7	2·8	85·4	88·3	11·8	10·1	8·4	9·0	235	270
Yearly average	95	91	0·29	0·29	2·8	3·1	83·2	86·4	12·5	10·7	8·5	8·9	245	260

B = Bronze; BW = Beltsville Small White.

Almost the same seasonal and monthly variations were observed in the semen characteristics of the two breeds, though Beltsville Small White turkeys gave high values compared with those for the Bronze breed. The tests of significance are shown in Table 2.

Sperm abnormalities

The abnormalities observed involved malformations of the sperm head (coiled, hooked, ruptured) or deformities of the tail (coiled, broken, absent). The latter were the more frequent. High percentages of head and tail abnor-

malities occurred during the long and hot days of May to September in both breeds (Table 3). Head and tail abnormalities decreased during the cold months of November to April. The percentages of tail and head abnormalities were higher for Bronze than for Beltsville Small White turkeys but both breeds showed almost the same monthly variations. The tests of significance are shown in Table 4. In general, an increase in head malformations coincided with an increase in the total abnormalities and a decrease in sperm concentration, motility and percentage of live spermatozoa.

TABLE 2

ANALYSIS OF VARIANCE OF SEMEN CHARACTERISTICS AS AFFECTED BY MONTHS, BREEDS AND INDIVIDUALS

Item	*Source of variation*	*Degrees of freedom*	*Mean square*
Semen volume	Months	11	0·1068*
	Breeds	1	0·0008
	Individuals	19	0·0251**
	Error	191	0·0058
Motility	Months	11	6·2213**
	Breeds	1	2·8231**
	Individuals	19	3·9857**
	Error	191	0·0904
% live sperm. in fresh semen	Months	11	107·4349
	Breeds	1	482·2000**
	Individuals	19	135·0120**
	Error	191	59·6230
% of total abnormals	Months	11	281·5517**
	Breeds	1	172·4599**
	Individuals	19	66·3456**
	Error	191	1·0106
Sperm concentration	Months	11	103·0979**
	Breeds	1	36·6265**
	Individuals	19	58·2886**
	Error	191	1·4488

* $P<0.05$; ** $P<0.01$.

Chemical components

Seasonal and monthly variations in seminal fructose and ascorbic acid were apparent and levels of inorganic phosphate were slightly higher during the spring and summer months than during the autumn and winter months (Table 5). Semen fructose and ascorbic acid were low from May to October and increased from November to March. A similar trend was observed with respect to semen quality.

Fructolysis. The metabolism of seminal fructose was accompanied by the production and increase of carbon dioxide. The metabolism of fructose was high during the first hour and decreased gradually thereafter (Tables 6 and 7). The summer months of hot weather coincided with high sperm concentrations and a higher fructose consumption during the first hour of incubation than at any subsequent times.

TABLE 3

MONTHLY VARIATIONS IN PERCENTAGES OF ABNORMAL SPERMATOZOA OF BRONZE AND BELTSVILLE SMALL WHITE TURKEYS

Month	*Head*										*Tail*							
	Total		*Coiled*		*Hooked*		*Ruptured*		*Others*		*Total*		*Coiled*		*Broken*		*Absent*	
	B	*BW*	*B*	*BW*	*B*	*BW*	*B*	*BW*	*B*	*BW*	*BW*	*BW*	*B*	*BW*	*B*	*BW*	*B*	*BW*
January	1·78	0·92	1·08	0·80	0·00	0·00	0·00	0·00	0·67	0·12	5·65	4·73	3·90	3·65	1·75	1·00	0·00	0·08
February	1·53	1·20	0·89	0·86	0·53	0·00	0·12	0·00	0·00	0·34	9·11	6·55	5·51	4·19	2·94	1·98	0·66	0·38
March	1·33	2·32	0·56	1·19	0·20	0·32	0·26	0·32	0·31	0·49	7·07	6·90	4·68	5·91	1·72	0·99	0·67	0·00
April	2·60	2·68	0·90	1·33	0·55	0·41	0·75	0·36	0·40	0·58	7·60	8·78	4·60	6·22	2·40	2·19	0·60	0·37
May	7·68	4·76	2·25	1·12	1·43	0·81	2·94	1·49	1·06	1·34	12·44	12·54	8·19	8·79	3·12	2·73	1·13	1·02
June	3·90	3·69	0·68	1·48	0·47	0·48	1·84	0·48	0·91	0·87	9·12	6·60	6·55	4·33	1·81	1·89	0·76	0·38
July	6·64	6·06	1·08	1·72	1·62	0·74	2·52	1·95	1·42	1·65	12·59	11·06	8·56	7·13	2·61	2·94	1·42	0·99
August	3·36	3·80	1·13	0·79	0·76	0·94	0·82	0·81	0·65	1·26	12·45	8·99	8·33	6·06	2·83	1·93	1·29	1·00
September	3·28	2·17	1·56	1·17	0·49	0·20	0·49	0·36	0·74	0·44	11·25	8·74	6·94	6·09	2·69	2·38	1·62	0·27
October	2·41	1·68	1·11	1·39	0·36	0·00	0·21	0·29	0·73	0·00	9·43	8·76	6·30	6·16	2·10	2·60	1·03	0·00
November	1·60	1·23	0·51	0·87	0·23	0·00	0·25	0·00	0·61	0·36	7·45	7·74	5·20	4·90	1·71	2·62	0·54	0·22
December	1·48	1·01	0·55	0·71	0·24	0·30	0·15	0·00	0·54	0·00	8·46	5·31	5·07	3·61	2·25	1·70	1·14	0·00
Yearly average	3·13	2·63	1·03	1·12	0·57	0·35	0·86	0·54	0·67	0·62	9·39	8·06	6·15	5·59	2·33	2·08	0·91	0·39

B = Bronze; BW = Beltsville Small White.

DISCUSSION

The increase in semen quantity in this study coincided with the period of hot weather which has been associated with reduced semen production (Parker, 1946). It seems, however, that, in localities similar to Giza in climate and where birds are kept out of doors during the summer, the effect of hot weather is offset by the recurring coolness of the nights. A similar effect was found by Burrows & Kosin (1953) and Kamar & Badreldin (1959a).

TABLE 4

ANALYSIS OF VARIANCE OF ABNORMALITIES AS INFLUENCED BY MONTHS, BREEDS AND INDIVIDUALS

Item	*Source of variation*	*Degrees of freedom*	*Mean square*
Coiled head	Months	11	2·7125**
	Breeds	1	0·4346
	Individuals	19	0·9063**
	Error	191	0·3586
Hooked head	Months	11	3·4630**
	Breeds	1	2·9845**
	Individuals	19	0·6006**
	Error	191	0·1498
Ruptured head	Months	11	13·3911**
	Breeds	1	7·1896
	Individuals	19	0·8313**
	Error	191	0·3148
Other forms	Months	11	4·2518**
	Breeds	1	0·2576
	Individuals	19	0·2066
	Error	191	0·2204
Coiled tail	Months	11	41·1995**
	Breeds	1	20·2349**
	Individuals	19	10·8379**
	Error	191	0·8003
Broken tail	Months	11	3·8904**
	Breeds	1	0·3123
	Individuals	19	2·3425
	Error	191	0·6002
Tailless	Months	11	4·9613**
	Breeds	1	16·9925**
	Individuals	19	1·6216**
	Error	191	0·0708

** $P<0.01$.

The finding of the smallest volumes of semen during the winter months agrees with that of Carson *et al.* (1955). The shorter days may depress spermatogenic activity and semen production. The complete cessation of semen production recorded by Carson *et al.* (1955) was not observed in the present study, a discrepancy which may have been due to differing local environmental conditions.

The low semen quality occurring during the summer months may be caused by the intense light and high air temperatures. There was a noticeable decline

in all semen characteristics during May which might have been due to the hot Khamasin winds prevailing during this period.

It was noted that the period of highest ejaculatory responsiveness coincided almost exactly with the period of highest sperm concentrations, sperm abnormalities and sexual activity. The large numbers of abnormalities were presumably a reflection of the large numbers of spermatozoa produced and the high sexual activity which did not allow the spermatids to be retained for

TABLE 5

MONTHLY VARIATIONS IN THE FRUCTOSE, ASCORBIC ACID AND INORGANIC PHOSPHATE OF SEMEN OF BRONZE AND BELTSVILLE SMALL WHITE TURKEYS

Month	*Fructose** (*mg*/100 *ml*)	*Ascorbic acid* (*mg*/100 *ml*)	*Inorganic phosphorus* (*mg*/100 *ml*)
December	5·97	2·23	8·55
January	5·65	2·76	7·63
February	6·74	2·81	9·04
Winter	5·93	2·75	8·30
March	7·52	2·65	9·13
April	7·61	2·22	9·54
May	3·52	1·77	8·02
Spring	6·22	2·21	8·90
June	3·84	1·96	9·34
July	3·33	1·76	9·57
August	3·22	1·62	8·84
Summer	3·46	1·78	9·25
September	4·50	1·89	8·00
October	3·64	2·21	7·60
November	4·70	2·37	7·71
Autumn	4·28	2·16	7·77
Yearly average	4·97	2·23	8·55

* Evaluated immediately after collection.

sufficient time to mature. Kamar & Badreldin (1959b) have suggested that spermatozoa with abnormal heads are always dead cells.

The somewhat higher values recorded in this study for the semen characteristics of the Beltsville Small White, compared with the Bronze, turkeys may be due to their greater adaptability to hot climates. The white colouring may be an important factor in such adaptation.

The seasonal similarity in the levels of fructose and ascorbic acid on the one hand and semen quality on the other suggests that the content of the former may influence the latter. Fructose is known to be an important source of energy for the metabolism of turkey spermatozoa (Pace, Moravec & Mussehl, 1952) and ascorbic acid may increase their motility.

TABLE 6

MONTHLY VARIATIONS IN THE FRUCTOSE OF SEMEN INCUBATED AT ROOM TEMPERATURE FOR DIFFERENT PERIODS FROM THE TIME OF COLLECTION FROM BRONZE AND BELTSVILLE SMALL WHITE TURKEYS

Month	*Initial fructose (mg/100 ml)*	*Rate of fructose consumption in first hour*	*Rate of fructose consumption in second hour*	*Rate of fructose consumption in third hour*	*Room temp. (°C)**
January	5·65	22·4	56·3	11·7	11·1
February	6·74	46·2	61·1	13·9	12·2
March	7·52	72·2	51·7	24·9	15·3
April	7·61	75·1	53·6	42·8	19·1
May	3·52	8·9	12·5	4·7	23·1
June	3·84	101·8	30·4	8·0	26·0
July	3·33	62·2	23·6	13·1	26·6
August	3·22	83·1	36·4	9·0	26·6
September	4·50	30·2	44·1	21·4	24·1
October	3·64	68·7	53·0	21·2	21·6
November	4·70	76·1	97·0	19·6	18·0
December	5·40	55·9	83·5	8·3	13·2
Yearly average	4·97	58·6	43·6	16·6	19·7

Rate of fructose consumption calculated as follows:
fructose consumed in first hour × 100/initial fructose,
fructose consumed in second hour × 100/fructose at beginning of second hour,
fructose consumed in third hour × 100/fructose at beginning of third hour.

* Mean of day (24 hr).

The gradual decrease in fructose metabolism after the first hour of incubation noted here, and also found by Mann (1948), may be due to progressive inactivation of the spermatozoa (Lorenz, 1958). The metabolism of fructose by large numbers of spermatozoa proceeds rapidly at first but is accompanied by the production of large quantities of CO_2 which gradually depresses sperm activity and viability (Kosin, 1958). Spermatozoa produced during the summer

TABLE 7

FRUCTOSE CONSUMED AND CO_2 PRODUCED IN SEMEN OF BRONZE AND BELTSVILLE SMALL WHITE TURKEYS AFTER DIFFERENT PERIODS OF INCUBATION AT ROOM TEMPERATURE*

Incubation period	*Fructose (mg/100 ml)*	*Rate of fructose consumption (%)*	*CO_2 formed (g)*
0 to 1 hr	2·16†	58·6	3·17
1 to 2 hr	1·06	49·1	1·55
2 to 3 hr	0·23	21·7	0·30
0 to 1 hr	2·16	58·6	3·17
0 to 2 hr	3·22	87·3	4·72
0 to 3 hr	3·45	93·5	5·06

* Room temperature = 19·7°C (yearly average).
† Initial fructose level = 3·69 mg/100 ml.

showed the most marked and consistent depression after the first hour of incubation. The smaller number of spermatozoa produced during the winter metabolized less fructose at first with the result that the smaller amounts of CO_2 produced had less effect on fructose consumption during the first hour. Subsequently, sperm activity as measured by fructose consumption was also less affected.

REFERENCES

ASLANJAN, C. J., SOROKE, M. F. & SINKARENKO, L. S. (1963) The artificial insemination of turkeys. *Ptitsevodstvo*, **6**, 18.

BURROWS, W. H. & KOSIN, I. L. (1953) The effect of ambient temperature on production and fertilizing capacity of turkey spermatozoa. *Physiol. Zoöl.* **26**, 131.

CARSON, J. D., LORENZ, F. W. & ASMUNDSON, V. S. (1955) Semen production in turkey male. I. Seasonal variation. *Poult. Sci.* **34**, 336.

HAWK, P. B., OSER, B. L. & SUMMERSON, W. H. (1947) *Practical physiological chemistry*, 12th edn. Blakiston, Philadelphia.

KAMAR, G. A. R. (1958) The collection of cock's semen without milking the copulatory organ. *Poult. Sci.* **37**, 1382.

KAMAR, G. A. R. (1959a) The differentiation of live from dead sperms in fowl semen. *Stain Technol.* **34**, 5.

KAMAR, G. A. R. (1959b) Semen characteristics of foreign and native fowls under Egyptian conditions. *Indian J. vet. Sci.* **29**, 19.

KAMAR, G. A. R. (1960) Studies on fowl sperm. *Emp. J. exp. Agric.* **28**, 16.

KAMAR, G. A. R. & BADRELDIN, A. L. (1959a) Seasonal variations in semen characteristics of adult Favoumi cocks. *Poult. Sci.* **38**, 302.

KAMAR, G. A. R. & BADRELDIN, A. L. (1959b) Sperm morphology and viability. *Acta anat.* **39**, 81.

KOSIN, I. L. (1958) Metabolism of turkey semen as affected by the environment of donor birds. *Poult. Sci.* **37**, 376.

LORENZ, F. W. (1958) Carbohydrate metabolism of cock spermatozoa. *Nature, Lond.* **182**, 397.

MANN, T. (1948) Fructose content and fructolysis in semen. *J. agric. Sci., Camb.* **38**, 323.

PACE, D. M., MORAVEC, D. F. & MUSSEHL, F. E. (1952) Physiological characteristics of turkey semen. I. Effect of type of diluent and degree of dilution on duration of motility in turkey semen. *Poult. Sci.* **31**, 577.

PARKER, J. E. (1946) Semen production in Broad Breasted Bronze turkeys. *Poult. Sci.* **25**, 65.

SNEDECOR, G. W. (1957) *Statistical methods*. Iowa State College Press, Ames.