ONTOGENY OF THE SUPERNUMERARY SESAMOIDS IN THE LEG MUSCLES OF THE RING-NECKED PHEASANT

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IT has long been known to hunters, game managers, gourmets, and, no doubt, to primitive man, that the shank muscles of grouse, certain pheasants and partridges, and turkeys contain numerous splinters of bone. In the fall hunting season these are present in all specimens of grouse, Mountain Quail (*Oreortyx pictus*), Gray Partridge (*Perdix perdix*), Ring-necked Pheasant (*Phasianus colchicus*) and turkey (*Meleagris gallopavo*), except occasionally in very young birds hatched unusually late. Occurrence of sesamoids in the legs of many genera of gallinaceous birds has been summarized by Hudson, Lanzillotti, and Edwards (*Amer. Midl. Nat.*, 61: 1–67, 1959; see pp. 46–47), and for the wing muscles by Hudson and Lanzillotti (*Ibid.*, 71: 1–113, 1964; see pp. 92–93). Similar structures occur in some members of the Gruiformes and Strigiformes (Hudson, *ibid.*, 18: 1–108, 1937).

The purposes of this investigation were to determine the age at which each leg sesamoid appears, the extent to which this varies, and whether the development of sesamoids could be used as an additional criterion for estimating the age of individuals.

MATERIALS AND METHODS

We obtained 40 Ring-necked Pheasants, hatched on 15 June 1957, from a commercial game farm near Spokane, Washington. When several weeks old these birds were placed in outdoor pens at Pullman, Washington. They were fed fortified growing mash and wheat to repletion and had access to grit, oystershell, and dry alfalfa hay. An additional 16 pheasants of known age, obtained from I. O. Buss, were used to supplement the observations on our birds; some of these had been bursectomized when very young.

On 2 August 1957, when our birds were 48 days old, we killed the first pair; one pair was killed each week until 8 November, and one pair per month from December through March. Birds were killed by decapitation. Legs were removed above the knee and kept in the deep freeze for several weeks. Later they were preserved in 1 : 10 formalin solution and eventually stored in 70 per cent ethyl alcohol. Data recorded for each specimen included sex, weight, length of tibiotarsus and tarsometatarsus, and length and width of gonad and bursa Fabricii.

Muscles were removed one at a time and the flesh stripped away from the tendon, exposing any sesamoids present. In some of the younger specimens alizarin red S dye was used to delineate the sesamoids in the process of ossification. After removal, each sesamoid was measured, while still wet, to the nearest 0.1 mm with a Vernier caliper, often with the aid of a dissecting binocular microscope. Each tendon, whether enclosing a sesamoid or not, was then glued under the proper muscle label on a sheet of paper and allowed to dry.

In a few newly developed sesamoids two or more separate centers of ossification were found; in such cases we measured from the extreme proximal to the distal

end, ignoring the gaps between. Some of these measurements in very young birds are only approximate since the limits of ossification are not always sharply defined. The ossified tendon of the gastrocnemius in the tarsal region could not be measured very accurately because of its fusion with the tarsometatarsus, especially in the case of birds with well developed spurs.

Although we measured the lengths of sesamoids in millimeters we have expressed these measurements in the tables and figures as percentages of the length of either the tibiotarsus or tarsometatarsus, depending on whether the sesamoid was located in the shank or the foot. Our abbreviations for muscle names follow Hudson *et al.* (1959), and are repeated herewith.

Tib. ant.	Tibialis anterior
Ext. dig. l.	Extensor digitorum longus
Per. long.	Peronaeus longus
Per. brev.	Peronaeus brevis
Gas., P. int.	Gastrocnemius, Pars interna
Gas., P. ext.	Gastrocnemius, Pars externa
Plan.	Plantaris
F. p. et p. d. II	Flexor perforans et perforatus digiti II
F. p. et p. d. III	Flexor perforans et perforatus digiti III
Flex. per. d. II	Flexor perforatus digiti II
Flex. per. d. III	Flexor perforatus digiti III
Flex. per. d. IV	Flexor perforatus digiti IV
F. hal. l.	Flexor hallucis longus
F. dig. l.	Flexor digitorum longus
Ext. hal. l.	Extensor hallucis longus
Ext. brev. d. IV	Extensor brevis digiti IV
F. hal. brev.	Flexor hallucis brevis
Abd. d. IV	Abductor digiti IV

DISCUSSION OF RESULTS

The results are summarized in Figures 1–4 and Tables 1–3.

Sesamoids in the process of developing were first noted in birds 55 days old (Tables 1, 2; Figure 1), at which age the female had 15 sesamoids definite enough to be measured, and the male only 2. Some others were indicated by vague traces. After 55 days most of the sesamoids formed rapidly, and at 83 days their development was nearly complete (Table 1, 2; Figure 1). At this time the birds were essentially full grown, as shown by measurements of the tibiotarsus and tarsometatarsus, although body weight continued to increase for several weeks. Sesamoid development was complete long before the bursa Fabricii disappeared.

The sesamoids in females developed somewhat earlier than in males, perhaps a week earlier or slightly more (Table 2, Figure 1); however, our sample is too small to establish this without question.

The 14 principal shank sesamoids and the 10 sesamoids in shank muscle tendons in the region of the tarsus were well developed at 83 days and all were invariably present thereafter. Three of the six short

TABLE 1

SUPERNUMERARY SESAMOIDS IN THE LEG MUSCLES OF 12 PAIRS OF RING-NECKED PHEASANTS OF KNOWN AGE

		Age in days										
		48	*55*	*62*	*69*	*76*	*83*	*104*	*118*	*131*	*146*[1] *174*	*239*
Sesamoids in Shank												
Tib. ant. (prox.)	♂				T[2]							
	♀							.04	.07	.10	.10	.04
Tib. ant. (dist.)	♂					.42[3]	.44	.46	.51	.48	.47 .45	.45
	♀		.20		.31	.46	.47	.46	.48	.48	.46 .46	.48
Ext. dig. l.	♂					.53	.58	.58	.60	.64	.64 .62	.63
	♀				.36	.56	.56	.59	.63	.66	.61 .64	.66
Per. long. (prox.)	♂						.13	.11	.10	.18	.09 .22	.16
	♀						.16	.12	.23	.16	.12 .12	.14
Per. long. (dist.)	♂		.14	.16	.22	.26	.31	.22	.26	.28	.24 .22	.24
	♀		.18	.18	.23	.22	.28	.22	.26	.27	.22 .25	.30
Per. brev.	♂		T	.22	.26	.32	.33	.36	.38	.39	.37 .38	.37
	♀		.24	.20	.28	.32	.34	.34	.41	.38	.36 .36	.38
Gas., P. int.	♂			.08	.12	.32	.34	.37	.39	.36	.32 .36	.39
	♀		T	.12	.27	.30	.38	.26	.37	.38	.38 .36	.36
Gas., P. ext. (prox.)	♂								.04	.04	.04	.08
	♀						.06		.10	.06		.10
Gas., P. ext. (dist.)	♂			T	.08	.14	.16	.12	.14	.16	.14 .12	.14
	♀		T	.05	.10	.12	.14	.11	.12	.18	.12 .10	.14
Plan	♂			T		.47	.48	.47	.52	.49	.46 .46	.52
	♀		T	.10	.39	.48	.49	.45	.52	.52	.48 .46	.51
F. p. et p.d. II	♂			T	.17	.49	.50	.40	.48	.50	.46 .42	.46
	♀		.10	.12	.38	.43	.46	.40	.46	.48	.43 .43	.46
F. p. et p.d. III	♂		.02	.14	.22	.49	.48	.48	.50	.53	.52 .48	.52
	♀		.30	.23	.42	.46	.52	.48	.54	.56	.50 .46	.52
Flex. Per. d. II	♂			.16	.25	.40	.39	.40	.42	.42	.43 .39	.42
	♀		.23	.22	.35	.34	.41	.38	.42	.43	.39 .38	.40
Flex. per. d. III (lat.)	♂					.12	.20	.12	.12	.22	.15 .12	.20
	♀					.14	.10	.15	.14	.23	.13 .14	.16
Flex. per. d. III (med.)	♂					.22	.20	.22	.26	.32	.24 .26	.27
	♀				.20	.26	.22	.24	.28	.30	.22 .24	.26
Flex. per. d. III (dist.)	♂			.09	.16	.28	.28	.27	.42	.32	.27 .24	.29
	♀		.18	.16	.22	.25	.25	.24	.30	.32	.28 .27	.34
Flex. per. d. IV	♂		T	.20	.25	.44	.44	.43	.30	.49	.43 .38	.46
	♀		.27	.24	.34	.38	.44	.40	.46	.47	.46 .42	.48
F. hal. l. (prox.)	♂											
	♀											
F. hal. l. (dist.)	♂			.20	.38	.64	.64	.66	.68	.70	.66 .70	.68
	♀		.27	.28	.49	.63	.68	.66	.70	.71	.67 .68	.70
F. dig. l.	♂			T	.16	.44	.54	.52	.56	.58	.54 .56	.60
	♀		T	T	.36	.47	.54	.56	.57	.58	.56 .56	.54

[1] Based on right leg only for male.

[2] T = Trace.

[3] The length of each sesamoid is expressed as a fraction of the length of either the tibiotarsus or tarsometatarsus. Figures are the average for right and left sides.

TABLE 1 (*Continued*)

		Age in days											
		48	*55*	*62*	*69*	*76*	*83*	*104*	*118*	*131*	*146*[1]	*174*	*239*
		Sesamoids in Tarsus											
Ext. dig. l.	♂		T	T	.56	.62	.72	.66	.68	.66	.68	.70	.66
	♀		.51	T	.68	.68	.68	.68	.69	.67	.70	.70	.69
Per. long.	♂		T			.10	.15	.14	.14	.15	.15	.18	.12
	♀				.14	.14	.18	.12	.16	.14	.16	.14	.15
Gas.	♂					.46	.68	.69	.72	.66	.72	.67	.68
	♀				.38	.52	.60	.62	.65	.62	.65	.66	.62
F. p. et p.d. II	♂				.49	.60	.67	.58	.59	.59	.58	.64	.62
	♀		T	.34	.63	.57	.62	.59	.62	.60	.58	.64	.62
F. p. et p.d. III	♂		T	.32	.62	.60	.64	.60	.59	.55	.59	.62	.59
	♀		.42	.44	.60	.58	.62	.60	.62	.60	.60	.62	.60
Flex. per. d. II	♂				.56	.59	.63	.60	.56	.58	.58	.58	.61
	♀		T	T	.60	.55	.61	.58	.60	.60	.58	.62	.60
Flex. per. d. III	♂		T	.48	.62	.64	.67	.66	.66	.62	.64	.66	.66
	♀		.55	.60	.64	.62	.68	.63	.68	.66	.68	.68	.65
Flex. per. d. IV	♂		T	.32	.60	.63	.68	.64	.62	.62	.63	.64	.65
	♀		.54	.49	.64	.62	.68	.62	.66	.64	.65	.65	.62
F. hal. l.	♂			T	.40	.42	.51	.44	.44	.48	.50	.46	.44
	♀		.33	.26	.52	.44	.53	.44	.46	.47	.39	.54	.41
F. dig. l.	♂			.42	.56	.61	.66	.62	.62	.62	.62	.64	.60
	♀		.34	.51	.63	.62	.62	.64	.64	.63	.64	.65	.64
Ext. hal. l.	♂												.04
	♀								T				
Ext. brev. d. IV	♂		T			.60	.62	.58	.64	.57	.55	.60	.60
	♀				.45	.58	.60	.57	.64	.62	.58	.56	.62
F. hal. brev.	♂		T				.09					.04	
	♀				.04	T	T		.16			.09	
Abd. d. IV	♂		T				.46	.50	.42	.41	.34	.26	.22
	♀				T	.34	.50	.37	.50	.49	.33	.44	.50

[1] Based on right leg only for male.

proximal sesamoids in the shank were consistently present as follows: after 83 days for the Per. long., and 76 days for the Flex. per. d. III (lat.) and the Flex. per. d. III (med.). The other three were variable in occurrence (Tables 1, 3).

Four of the short foot muscles may have sesamoids but only two had them consistently: the Ext. brev. d. IV from 76 days and the Abd. d. IV from 83 days on. Occurrence of sesamoids in the Ext. hal. l. and F. hal. brev. was very irregular (Table 3). Whether or not these variable sesamoids eventually appear in all specimens must be determined by examination of birds older than those available to us; however, we doubt that older birds would show much if any increase over the figures shown in Table 3. The total number of sesamoids in the hind limb, not count-

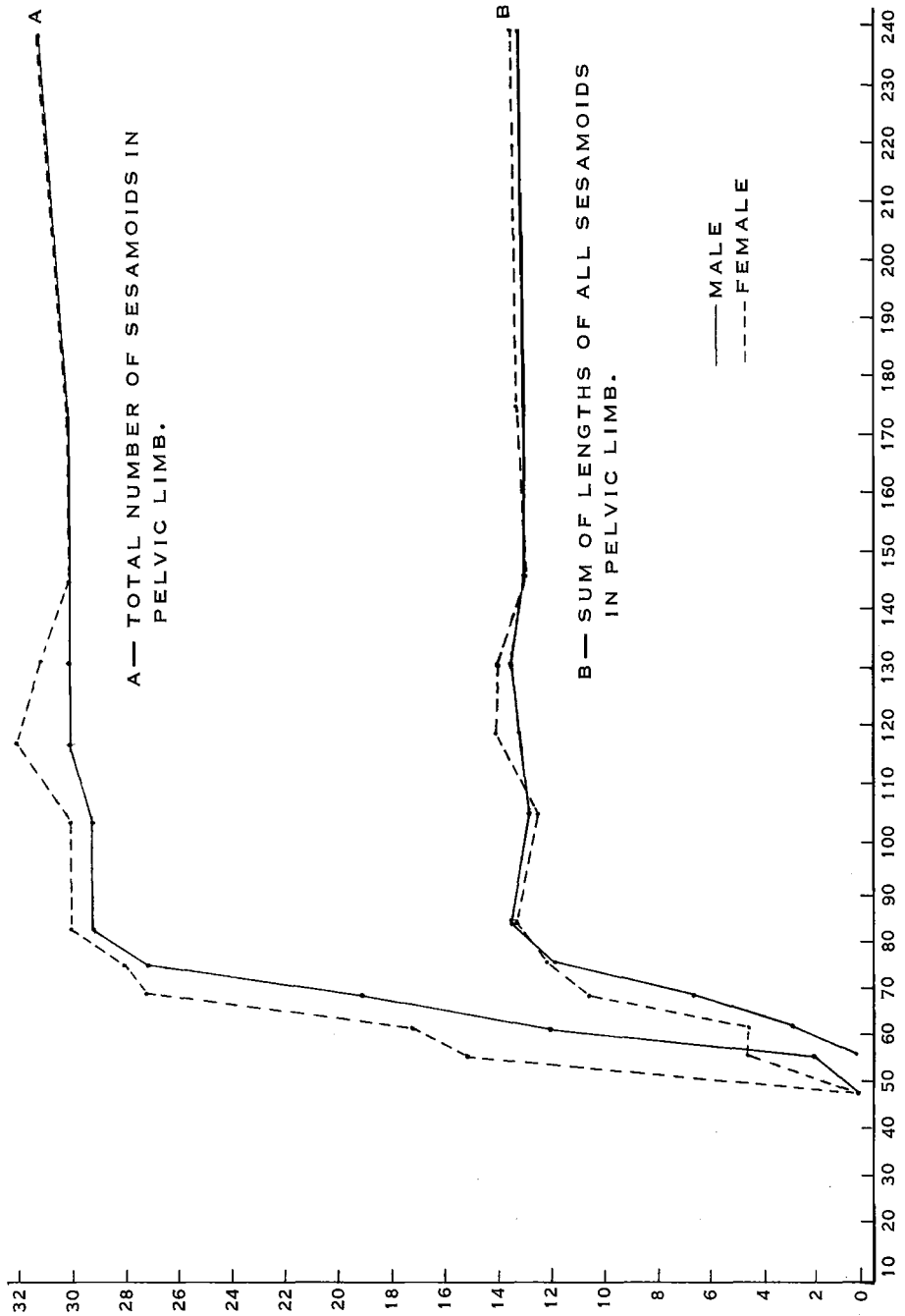

Figure 1. Sesamoids in pelvic limb muscles of the Ring-necked Pheasant. Sum of lengths of all sesamoids was obtained by adding the figures in Table 1 for birds of a given age.

TABLE 2

SUMMARY OF SESAMOIDS IN LEG MUSCLES OF 12 PAIRS OF RING-NECKED PHEASANTS OF KNOWN AGE

	Principal shank sesamoids		*Proximal shank sesamoids*		*Sesamoids in shank muscle tendons in tarsus*		*Foot muscle sesamoids*		*Totals*	
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
48 Days										
No. sesamoids	0	0	0	0	0	0	0	0	0	0
Sum of lengths	0	0	0	0	0	0	0	0	0	0
55 Days										
No. sesamoids	2	9	0	0	0	6	0	0	2	15
Sum of lengths	0.16	1.97	0	0	0	2.69	0	0	0.16	4.66
62 Days										
No. sesamoids	8	11	0	0	4	6	0	0	12	17
Sum of lengths	1.25	1.90	0	0	1.54	2.64	0	0	2.79	4.54
69 Days										
No. sesamoids	11	14	0	1	8	10	0	2	19	27
Sum of lengths	2.27	4.50	0	0.20	4.41	5.46	0	0.49	6.68	10.65
76 Days										
No. sesamoids	14	14	2	2	10	10	1	2	27	28
Sum of lengths	5.64	5.42	0.34	0.40	5.27	5.34	0.60	0.92	11.85	12.08
83 Days										
No. sesamoids	14	14	2	4	10	10	3	2	29	30
Sum of lengths	5.91	5.96	0.40	0.54	6.01	5.82	1.17	1.10	13.49	13.42
104 Days										
No. sesamoids	14	14	3	4	10	10	2	2	29	30
Sum of lengths	5.74	5.55	0.45	0.55	5.63	5.52	1.08	0.94	12.90	12.56
118 Days										
No. sesamoids	14	14	4	5	10	10	2	3	30	32
Sum of lengths	6.16	6.24	0.52	0.82	5.62	5.78	1.06	1.30	13.36	14.14
131 Days										
No. sesamoids	14	14	4	5	10	10	2	2	30	31
Sum of lengths	6.34	6.42	0.76	0.85	5.53	5.63	0.98	1.11	13.61	14.01
146 Days										
No. sesamoids	14	14	4	4	10	10	2	2	30	30
Sum of lengths	5.95	5.92	0.52	0.57	5.69	5.63	0.89	0.91	13.05	13.03
174 Days										
No. sesamoids	14	14	3	3	10	10	3	3	30	30
Sum of lengths	5.78	5.83	0.60	0.50	5.79	5.90	0.90	1.09	13.07	13.32
239 Days										
No. sesamoids	14	14	4	5	10	10	3	2	31	31
Sum of lengths	6.17	6.27	0.71	0.70	5.63	5.60	0.86	1.12	13.37	13.69

ing the patella and the one in the tibial cartilage, is 34; the maximum number found in any one specimen was 32.

All except five of the sesamoids shown in Figure 5 are from a male 174 days old. The five sesamoids, which are variable in appearance, taken from other specimens are those from the Gas. (prox.), Tib. ant. (prox.), F. hal. l. (prox.), F. hal. brev., and Ext. hal. l. The Gas. sesamoid in the tarsus is not shown; it is firmly fused to the tarsometatarsus.

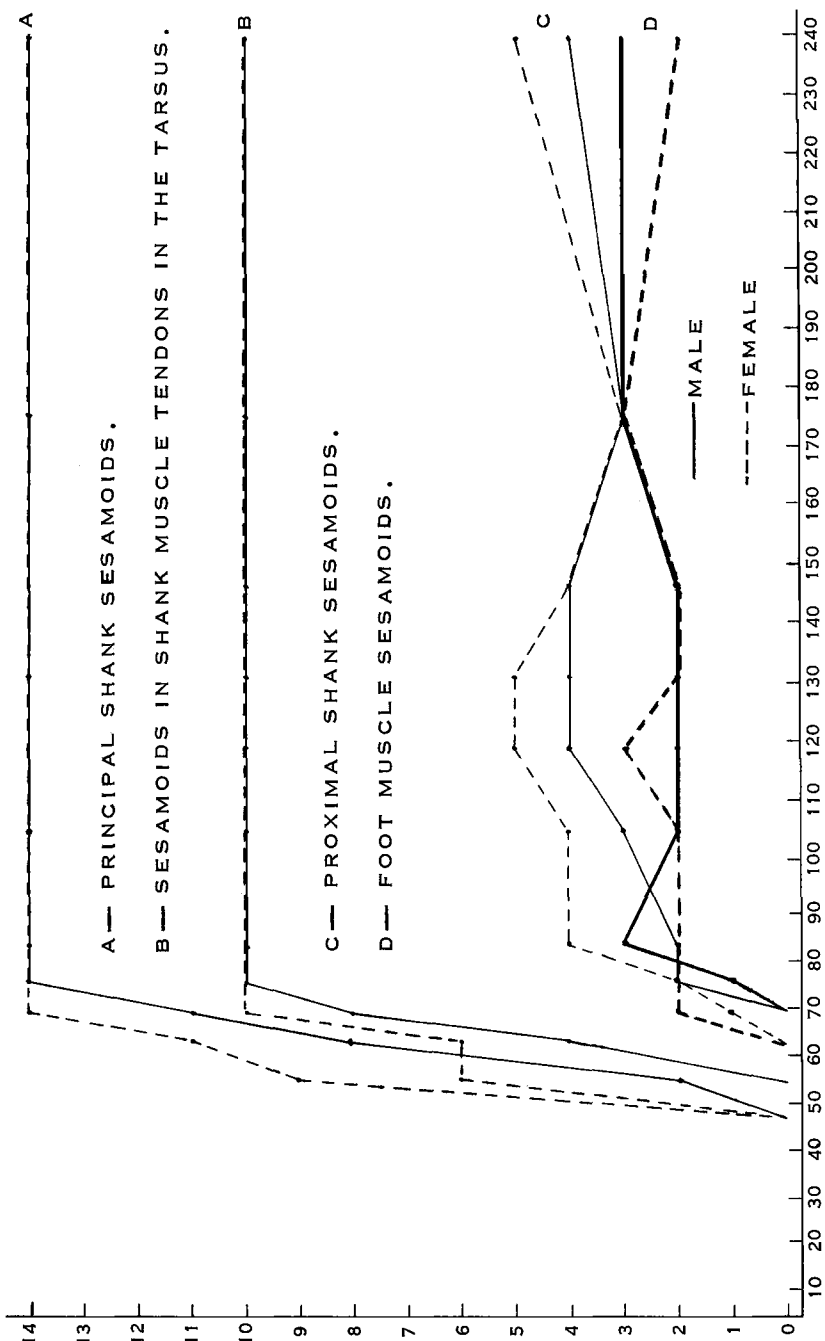

Figure 2. Number of sesamoids in different parts of the pelvic limb in the Ring-necked Pheasant.

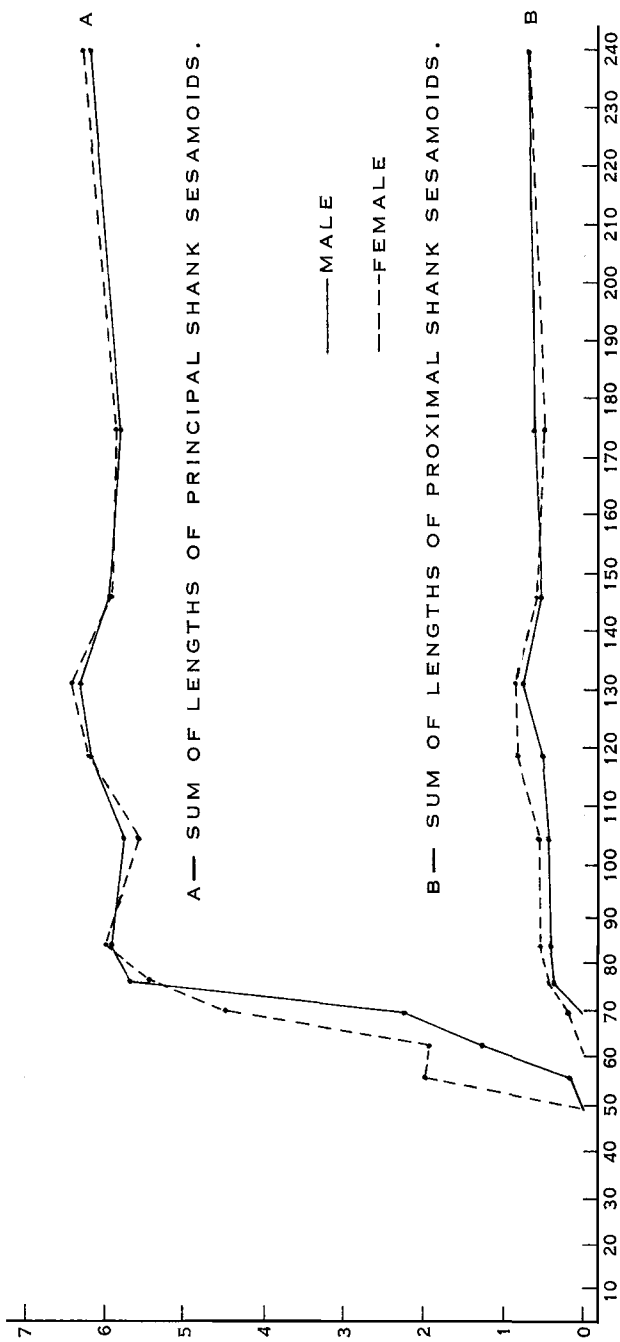

Figure 3. Sum of lengths of sesamoids in muscles in the shank of the Ring-necked Pheasant.

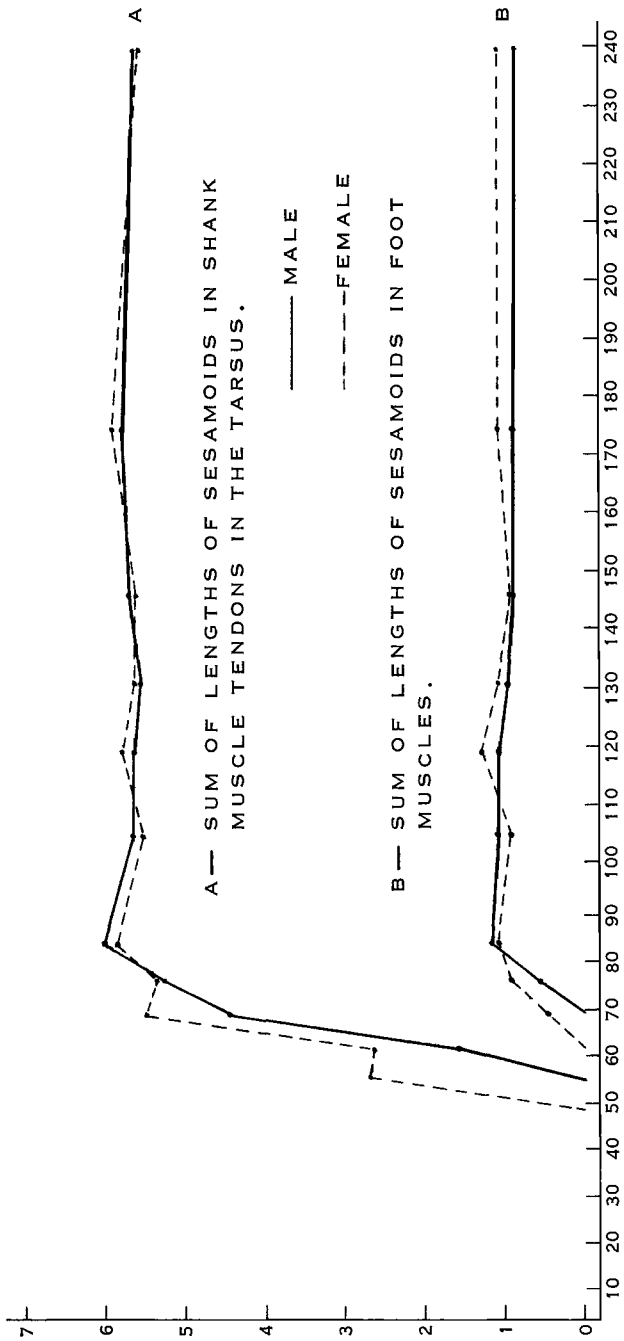

Figure 4. Sum of lengths of sesamoids in the tarsus of the Ring-necked Pheasant.

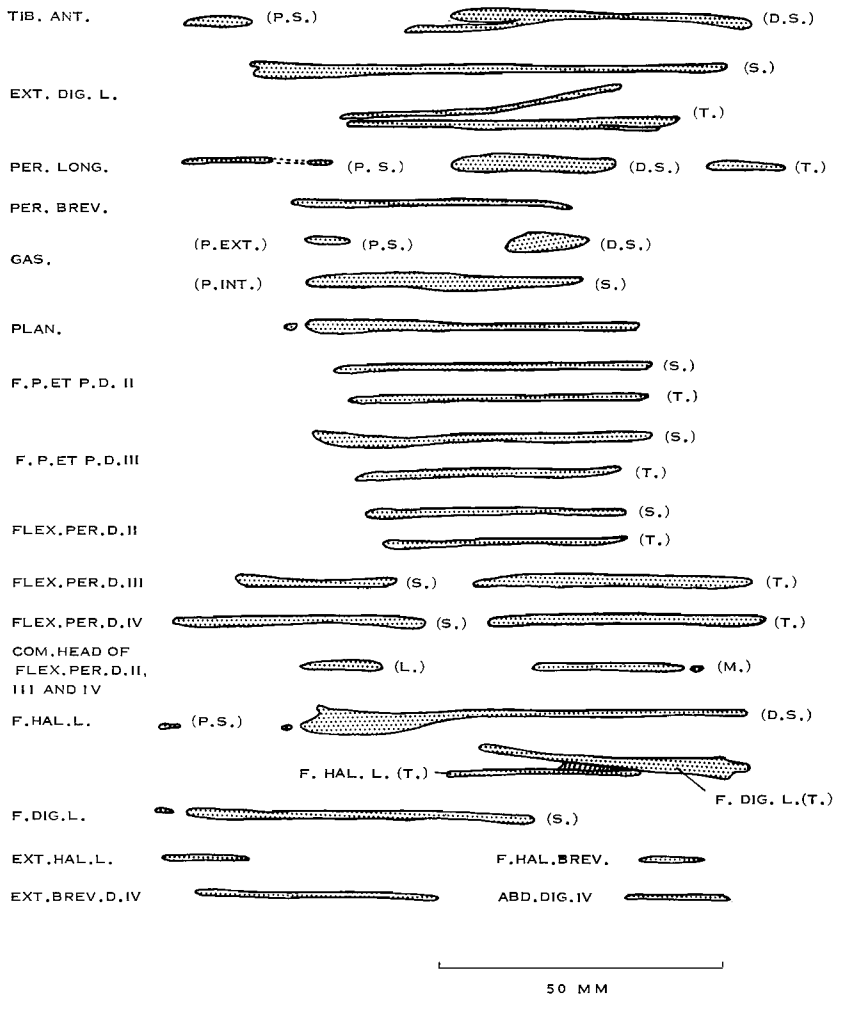

Figure 5. Supernumerary sesamoids from the pelvic limb muscles of the Ring-necked Pheasant. S., from shank; P.S., from proximal shank; D.S., from distal shank; T., from tarsus; L., lateral; M., medial.

Although females showed a somewhat more rapid development of sesamoids, the final number acquired and the final sum of the relative lengths of all sesamoids was very similar in both sexes (Table 2, Figures 1–4). The actual measurements were, of course, larger in the males (±9 per cent). A much larger sample would be required to show whether or not sexual differences exist in the relative size of particular sesamoids.

TABLE 3

OCCURRENCE OF VARIABLE SESAMOIDS IN LEGS OF 50 RING-NECKED PHEASANTS OF KNOWN AGE

		Number	*Tib. ant. (prox.)*	*Gas. P. ext. (prox.)*	*F. hal. l. (prox.)*	*Ext. hal. l.*	*F. hal. brev.*
Less than	♂	10	10[1]	0	0	0	10
100 days old	♀	9	11	22	0	0	11
100–200	♂	9	11	33	0	11	11
days old	♀	8	88	50	0	38	25
200–481	♂	11	54	27	9	27	18
days old	♀	3	67	100	0	0	33
Mean for all over 100 days old		31	52	42	3	23	19
Bilaterality[2]							
In both legs			81	92	0	50	71
In one leg only			19	8	100	50	29

[1] Percentage of specimens having the sesamoid in one or both legs. In 6 of the 50 specimens only one leg was available.

[2] Figures based only on complete specimens having the sesamoid present.

Since the sesamoids develop rapidly when pheasants are about two months old they are of no practical value in age estimation.

In taxonomic studies in which the presence or absence of certain sesamoids is considered, it is useful to know in the case of subadult specimens whether or not the absence of particular sesamoids is due to immaturity. Our observations on the Ring-necked Pheasant suggest that if any sesamoids are well developed, it is probably safe to assume that the number present is close to the maximum for the species, except for a few small ones that are subject to great variation. Our observations of young gallinaceous birds taken in the fall hunting season, and of peafowl (*Pavo cristatus*) reared in captivity, tend to confirm this.

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