INBREEDING AMONG PEN-REARED QUAIL

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THE effect of inbreeding in wildlife species has received attention from several sources. Recently the 'inbreeding theory' as a possible explanation of cycles in game populations was given careful consideration by a group of wildlife experts and geneticists. Scott's symposium (1944) consisting of comments received from eight authorities revealed unanimity in a decision that inbreeding is not the causative factor. A few quotations from this illuminating article are in order:

"It is not difficult to cite a few examples which show quite clearly that inbreeding when it does occur among wild animals is not necessarily harmful."—SWANSON.

"It is apparent that nature has devised a good system for dispersion of populations under normal circumstances."—SWANSON.

"Cycles are due to factors in no way related to inbreeding."—STEEN.

"Inbreeding, in the sense probably intended by the supporters of this theory, is not, and never was supported by evidence. Some of the most stable populations in existence are the most inbred.—Any analogy with poultry and domestic animals is not valid because these are impure races full of inherited defects, and it is well known that inbreeding of inherited defects produces degeneration. On the other hand, the evidence is just as good that the inbreeding of pure races does not."—LEOPOLD.

"There is no evidence that inbreeding occurs in wild populations. . . . There is ample proof in the case of at least two of the quail that the fall shuffle does away with any necessity for and probably any possibility of inbreeding. . . . The work of geneticists on domestic animals indicates no deterioration through inbreeding, except where similar defects exist in both parents. . . . Ill results from inbreeding are not so much due to the kinship of blood as to the kinship of defect. When superior animals are individually adapted to each other and have no common weakness in their lineage, their common relationship has proved an advantage in producing superior progeny. It seems, then, that if inbreeding does occur it isn't necessarily deleterious."—KING.

In full agreement with this unanimous expression, a famous authority on quail, Herbert Stoddard, (1931) declares that in the progress of the Cooperative Quail Investigation conducted during 1924–29: "No evidence of harmful inbreeding was encountered in the five years of intensive field work in the Southeastern States." He continues: "So far as we are aware, it has never been definitely proved that inbreeding alone has ever been responsible for deterioration in any wild race, either of birds or of mammals, nor have laboratory experiments with the closest kind of inbreeding from *sound stock* through many generations indicated that such a condition is to be expected under natural conditions." Stoddard discusses conditions that "contribute to a thorough 'shuffling' of the stock before the nesting time. Hence there is little possibility of close inbreeding on normally stocked quail ground."

Thus, so far as the 'inbreeding theory' with related 'shoot-them-up' policy is concerned, there seems to be sufficient evidence to prove its fallaciousness. The consensus of many geneticists and conservationists, according to King of Scott's symposium, is "that there is no reason for believing that inbreeding occurs to any extent among wild animals, and second, there is no reason for believing that it would result in any great harm if it did occur."

On the other hand, Jull (1938) presents evidence to show that, in the case of chickens, "hatchability often decreased as the intensity of inbreeding increases. . . . The deleterious effects of inbreeding on hatchability are shown to be due largely to increased embryo mortality during the first four and especially the last three days of incubation." Crossbreeding, on the other hand, "tends to increase hatchability."

QUAIL BREEDING AT PATUXENT RESEARCH REFUGE

That intense inbreeding and crossbreeding of quail in captivity can produce results similar to that obtained with chickens is indicated by an experience of the writers in conducting nutrition studies with quail in the period 1939–42. Four experiments were conducted at the Patuxent Research Refuge, Bowie, Maryland, with breeding Bobwhites, to determine the optimum level of crude protein intake for maintenance and reproduction. In the first two experiments, involving 48 pairs of quail each, six protein levels from 13 to 23 per cent, inclusive, were compared; in the last two experiments, involving 96 pairs of quail each, six protein levels from 19 to 29 per cent, inclusive, were compared. The same levels of calcium, phosphorus and vitamin D were maintained in all four experiments. The approximate vitamin A and carotene content of the diets in International Units per pound of feed varied as follows: Exp. 1 — 10,800; Exp. 2 — 11,800; Exps. 3 and 4 — 16,800. The approximate riboflavin content in micrograms per pound of feed varied as follows: Exp. 1 — 2,000; Exp. 2 — 2,800; Exp. 3 — 2,600; and Exp. 4 — 2,200. The approximate thiamin potency of the diets in International Units per pound of feed was as follows: Exp. 1 — 250; Exp. 2 — 450; Exps. 3 and 4 — 550.

Two auxiliary experiments, designated as 2A and 3A, that were conducted simultaneously with Experiments 2 and 3, respectively, and had diets similar to those used in the latter experiments, gave data valuable for this discussion. Each consisted of 24 pairs of quail. Unfortunately, Experiment 3A had to be discontinued before the close of the breeding season because of need of its equipment for other purposes. Therefore the egg production record of this experiment is for only two-thirds of the season.

The initial stock of quail was of pen-reared birds from the Virginia State Game Farm at Camp Lee, Virginia. No breeding records were kept on them, but it is understood that they all came from the same strain of Bob-whites, namely, those propagated by Colonel Schwenck of Petersburg, Virginia. These birds were placed directly on Experiment 1.

The hatch of the eggs from eight of the 48 pairs was exceptionally good in comparison with the others. Therefore, offspring from these eight pairs were saved for Experiment 2. As shown in Table 1, 36 pairs of quail on Experiment 2 consisted of brothers and sisters, and 12 pairs consisted of males mated to unrelated females (so far as our records indicate), both from the select 'eight.' The birds used in

TABLE 1

HATCH OF EGGS FROM OFFSPRING OF QUAIL WITH EXCELLENT RECORD OF PERFORMANCE (EXPERIMENT 2)

Pedigree No.	*Hatch (%) of eggs from parents during previous year*	*Number of pairs*		*Hatch (%) of eggs from daughter mated to*	
		Sib matings	*Out-bred*	*Brother*	*Unrelated male*
F 103	95	10	6	59	73
B 29	93	6	1	55	76
E 95	93	6	1	34	50
B 21	78	6	0	41	—
D 31	90	3	0	46	—
E 75	82	1	3	39	55
F 83	75	3	1	37	38
E 79	81	1	0	33	—

Experiment 2A were mated at random without regard for the record of the parents; a few of the birds were inadvertently taken from the select group.

The 192 quail used in Experiment 3, conducted in 1941, consisted of the following stock:

1. Young stock, offspring of:
   - (a) outbred breeders on Experiment 2A 96
   - (b) outbred breeders on " 2 18
   - (c) inbred breeders on " 2 1
   - (d) outbred breeders off experiment 5
2. Young males from Oxford, Pa. 48
3. Female yearlings from Experiments 2 and 2A 24

The 24 female yearlings, together with the same number of young females, were paired off with Pennsylvania males, obtained by exchange from a large quail breeder in that state, whereas the rest of the local stock was paired off at random.

In Experiment 3A, half of the pairs consisted of brothers and sisters that were offspring of the sib matings made during the previous year; the other half consisted of female offspring from the aforementioned sib matings, crossed with Pennsylvania quail.

The birds in Experiment 4 were mated at random without regard for pedigree. However, yearlings were paired together, and young birds together.

RESULTS

Inasmuch as 161 of the 1278 chicks (12.6 per cent) that hatched in Experiment 1 were helped out of their shells because of their inability to hatch by their own strength, the percentage of hatch as given in Table 2 is high. If all of these assisted chicks were considered as dead

TABLE 2

REPRODUCTION OF BOB-WHITE ACCORDING TO SEVERAL METHODS OF BREEDING

Year	*1939*	*1940*			*1941*				*1942*
Experiment No.	*1*	*2*		*2A*	*3*		*3A**		*4*
Breeding	*Outbred*	*Inbred-sibs*	*Outbred-special*	*Outbred*	*Outbred*	*Crossbred*	*Inbred-sibs F from sib-lings*	*Crossbred-F from sibs × Pa. quail*	*Outbred*
Eggs produced during season; average number	43	41	41	47	52	60	32	41	65
Fertile eggs, per cent	94	89	92	90	93	93	88	94	94
Hatchable fertile eggs, per cent	82	49	66	76	69	70	66	64	79

* Experiment 3A was conducted for only two-thirds of the breeding season.

in the shell, the percentage of hatch would drop from 82 to 71, and thereby be comparable to the hatch of eggs from the outbred quail of the subsequent year. Likewise the percentages given in the second column of Table 1 would be somewhat lower. In 1940, only 18 chicks were assisted out of the shell, and thereafter the practice was discontinued.

However, even when the percentage of hatch for 1939 is left at the higher figure, the difference between that and the hatch of eggs from the outbred birds in Experiment 2A is not statistically significant.

The difference between the hatch of the outbred birds in Experiment 2 as well as Experiment 2A, and that of the inbred breeders in Experiment 2, is highly significant (odds of 99 : 1 by Fisher's t test),

whereas the difference in hatch between the two groups of outbred quail is not significant. Table 1 shows that in the case of offspring from Mating No. F 103, those that were outbred showed 16 per-cent-units better hatch for their eggs than those that were inbred. Differences in production and fertility of eggs for 1939 and 1940 were inconsequential.

In 1941 the hatch on both breeding experiments, 3 and 3A, showed parity with that of the outbred stock of 1940. Singularly, in Experiment 3A the hatching results from the inbred siblings, F generation of the sib matings of 1940, were as good as that from the cross matings. The egg production, however, was significantly lower. Once again, fertility was not affected by the methods of mating.

The results in 1942 are considered normal for pen-reared quail. Egg production was higher than in any of the previous years but not unusually so. Hatchability as well as fertility of the eggs was very good in the light of other propagators' records.

Eight females from Experiment 2, six from brother-sister matings and two from out-matings, were continued as breeders in Experiments 3 and 4. In 1941 they were crossbred with the Pennsylvania strain of Bob-white, and in 1942 they were outbred with quail from Patuxent Research Refuge. Table 3 shows a progressive improvement throughout the three years, from 50 to 81 per cent in the hatch of eggs from

TABLE 3

HATCH OF EGGS FROM QUAIL HENS THAT WERE INBRED IN 1940, CROSSBRED IN 1941 AND OUTBRED IN 1942, COMPARED WITH THOSE FROM HENS OUTBRED ALL THREE YEARS

Bird No.	*Pedigree No.*	*Year*			
		1940		*1941*	*1942*
		Inbred or Outbred	*% hatch*	*% hatch*	*% hatch*
237	B 29	Inbred	56	82	91
202	F 103	Inbred	57	72	79
707	F 83	Inbred	21	55	67
826	F 103	Inbred	54	67	76
457	F 103	Inbred	73	76	97
588	E 79	Inbred	33	86	77
(*Weighted*	*average*)	Inbred	50	73	81
256	E 71	Outbred	69	66	67
333	F 103	Outbred	81	75	80
(*Weighted*	*average*)	Outbred	75	70	74

the first group, whereas no improvement occurred in the hatch of the second group.

DISCUSSION AND CONCLUSION

The observations herein reported were not made on experiments designed as genetic or breeding studies (with the exception of Experiment 3A), but as dietary studies. Therefore there are certain weaknesses in the data that demand further investigation especially planned on this subject before conclusions can be drawn. However, the results reported in this paper do indicate that close breeding of quail can have deleterious effects on reproduction.

The brother-and-sister matings herein reported were forced upon quail in captivity by the whims of man. In the wild, it is doubtful that any appreciable number of birds would mate as closely as the twelve pairs in Experiment 3A.

The one condition in the wild under which inbreeding might play a deciding rôle, is when a species has been decimated to such few members that inbreeding is the only hope of survival. One notable example is the complete destruction of the Heath Hen, or 'Eastern Pinnated Grouse.' At one time this bird was found in large numbers in Massachusetts, southern New Hampshire, New York, Pennsylvania, and New Jersey. Its last stand was on the island of Martha's Vineyard, Massachusetts, where it existed for many years after its extirpation in other sections of the country. In 1930, only one bird of this species could be found there. The Passenger Pigeon shared a similar fate; and the beautiful Trumpeter Swan may soon follow these ill-fated creatures into oblivion. Close breeding may contribute to the final demise of a species.

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