Abnormal Mating Behavior and Reproductive Dysfunction Caused by Mercury in Japanese Quail[1] (37567)

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Despite the concerted efforts of conservationists, the list of endangered avian species is increasing rapidly. Mercury (Hg) has been implicated as a major contributing factor because of its widespread distribution as a toxic pollutant (1, 2). Hg poses a hazard to birds because it causes a loss in the reproductive potential of females. The reported reasons for this effect are egg shell-thinning and an increase in the numbers of infertile eggs (3, 4). However, the effects of Hg on the reproductive potential of male birds has not been reported. The objectives of this study were: (i) to examine egg production, reproductive efficiency and mating behavior in female Japanese quail (*Coturnix coturnix japonica*); and (ii) to determine the relationship of dietary Hg to the reproductive efficiency and mating behavior of the male of the species.

Materials and Methods. The quail were reared in colony cages for 5 wk and thereafter in mating cages. The dimensions of the mating cages were $20 \times 18 \times 19$ cm. The lighting program consisted of continuous artificial light (24 hr) for the first week, 8 hr of light during weeks 2 through 5, and 14 hr of light starting at week 6 until termination of the experiments at 8 wk.

Hg in the form of $HgCl_2$ was added to tap water at the level of 125 μg/ml. This level of Hg was available *ad libitum* to the quail in the drinking water from hatching until termination of the experiments. The control quail received drinking water without $HgCl_2$ and both the Hg-treated and control quail were fed a game bird ration which was devoid of Hg.

Fourteen control (Mc) and 14 Hg-treated (MHg) males were used along with 28 control (Fc) and 28 Hg-treated (FHg) females. The matings were performed by transferring a male to a cage in which 2 females were housed. The male was allowed to remain with the females for 15 min (0800 to 0815) daily for 14 consecutive days. The transfers of the males were made on a rotating basis, *i.e.*, each male was transferred to a different female cage at each mating interval. Thus, the Mc and MHg quail were transferred to each cage which contained females (either Fc or FHg) twice during the 14-day experimental period.

Results. The number of mating attempts which was recorded among the treatment groups is presented in Table I. The number of mating attempts which occurred when FHg + Mc, Fc + MHg and FHg + MHg quail were mated was significantly ($p < 0.01$) less than the number of attempts between matings of Fc + Mc quail. A 2×2 factorial analysis of variance showed that the mating behavior of the males was affected more severely by Hg than was the behavior of the females. A significant reduction in the number of mating attempts was recorded among the Fc or FHg + MHg quail than in the Fc or FHg quail. These data indicate that Hg inhibited the mating behavior of both female and male quail. This conclusion is supported by information which was gained by observing the quail during the daily mating periods. The MHg quail lacked the normal aggressive mating behavior of the Mc quail. The initial reaction of the MHg quail upon entering the mating cages was to feed and then avoid or escape the females. The FHg quail exhibited an avoidance re-

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TABLE I. Reproductive Efficiency of Japanese Quail Which Received $HgCl_2$ in the Drinking Water.

Mating[ab]	Av no. mating attempts[c]	Fertile eggs (%)	Hatch of fertile eggs (%)	Age of female at first egg (days)	Egg production (quail hen-housed basis)[d] (%)
Fc + Mc	3.9^1	75.0^1	83.8^1	37	77.8^1
FHg + Mc	1.7^2	9.1^2	25.3^3	45	7.4^2
Fc + MHg	0.7^3	10.9^2	49.5^2	37	77.8^1
FHg + MHg	0.9^3	0^3	No fertility	45	7.4^2

[a] Fc and Mc female and male controls received no $HgCl_2$ in the drinking water; FHg and MHg females and males received 125 μg Hg/ml in the form of $HgCl_2$ added to the drinking water from hatching until termination of the experiment at 49 days.

[b] One male was allotted 15 min (0800 to 0815) daily for 14 consecutive days with 2 females. A rotating placement mating scheme was used so that each of the 14 control and Hg-treated males were introduced to the 14 pairs of control and Hg-treated females only twice during the 14 day experimental period.

[c] Means within a column which possess a different superscript differ significantly ($p < 0.01$). Statistical comparisons were made by analysis of variance or by a 2×2 factorial analysis of variance. The means were separated by Duncan's new multiple range test (9).

[d] Percentage egg production on a quail hen-housed basis indicates the mean daily egg production per control or Hg-treated female using the original number of quail housed.

sponse similar to that of the MHg quail. Even though the FHg quail lacked normal receptiveness, they were overpowered by the more aggressive Mc quail. The abnormal mating behavior of both the MHg and FHg quail was readily apparent even to individuals who were witnessing Japanese quail matings for the first time.

The reproductive efficiency of the FHg quail was reduced drastically (Table I). The percentage fertile eggs and the percentage hatch of all eggs which were laid were reduced by Hg treatment. The first egg was laid and 50% production (quail hen-housed basis) was recorded in the Fc quail during week 6. The first egg was recorded during week 7 in the FHg quail. The maximum rate of egg production reached only 25% in this group. The FHg quail did not maintain sustained egg production. The greatest number of eggs laid on consecutive days by any FHg quail was only 3. Embryo mortality was negligible in all the groups and no deformed embryos or hatched chicks were found. The mean number of ova per female which showed initiation of rapid growth in the FHg quail at necropsy was 2.39 as compared to 6.97 in the Fc quail and this represents a significant ($p < 0.01$) reduction. The maturing ova of the FHg quail exhibited signs of atresia.

The mean relative testes weight (mg/100 g body weight) of the MHg quail at necropsy was significantly ($p < 0.01$) less than the controls. The weights were 5.88 in the MHg quail and 16.85 in the Mc quail. Histological examination indicated that a normal cellular continuity of the testes existed in the Mc quail (5) (Fig. 1A). Fewer spermatogonia, primary and secondary spermatocytes and spermatids were found in the MHg quail (Fig. 1B). It appeared that a normal component of interstitial cells was present in the testes of both Mc and MHg quail. These data suggest that Hg altered gametogenesis in both females and males.

The secondary sex characters of the FHg and MHg quail did not differ from the controls, *i.e.*, body size, conformation, crowing in males and coloration were normal. Other than by mating behavior, it was not possible to ascertain which quail were treated with Hg.

Discussion. One possible explanation for the findings of this study is that Hg selectively inhibited the production of follicle stimulating hormone (FSH) and/or luteinizing hormone (LH). The specific functions of these gonadotropins in avian species are not fully agreed upon (6); however, as in mam-

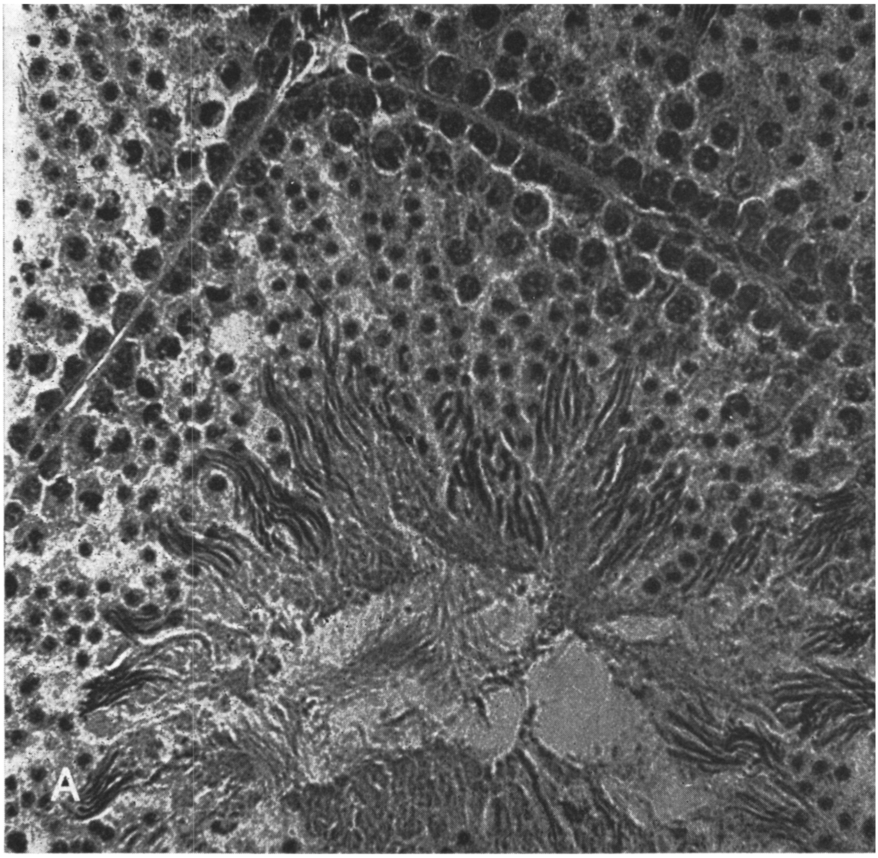

FIG. 1A. A medial cross-section of the testes of the control males (0 ppm Hg) showing characteristic histological continuity. (B) A similar section from males which received 125 ppm Hg. A reduction in the numbers of spermatogonia, primary and secondary spermatocytes, and spermatids is apparent. Both sections (A and B) demonstrate a normal component of interstitial cells. The sections were cut at 8 μm and stained with hematoxylin and eosin.

mals FSH and LH control gametogenesis and influence the circulating levels of the sex steroid hormones by acting in a conjunctive effort or as independent hormones (6). It is not possible to determine from these results whether Hg selectively affected the secretion of one or both of these gonadotropins. This hypothesis is warranted because of: (i) the reduction in the number of eggs laid, egg production rate, the event of first egg in the FHg quail; (ii) the apparent reduction of spermatogenesis in the MHg quail; and (iii) the finding of normal secondary sex characters in both the FHg and MHg quail. However, the abnormal mating behavior of the quail which consumed Hg is difficult to explain since the sex hormones, which are mediated by the gonadotropins, are integral to normal mating behavior (6). Possibly, Hg caused single or multiple lesions in nerves which are necessary for the control of the physiological processes essential to normal mating behavior. Dietary Hg is reported to cause neurological dysfunction in the red-tailed hawk (*Bueto jamaicensis*). Histopathological examination of the hawks revealed that Hg caused lesions in the myelin sheaths of certain spinal nerves (7). In another report when Hg was administered to pregnant rats, the offspring exhibited behavioral deviations (8). These findings and the results of the present study support the hypothesis of other workers (7, 8) that Hg induces neurological dysfunction which is at least partially

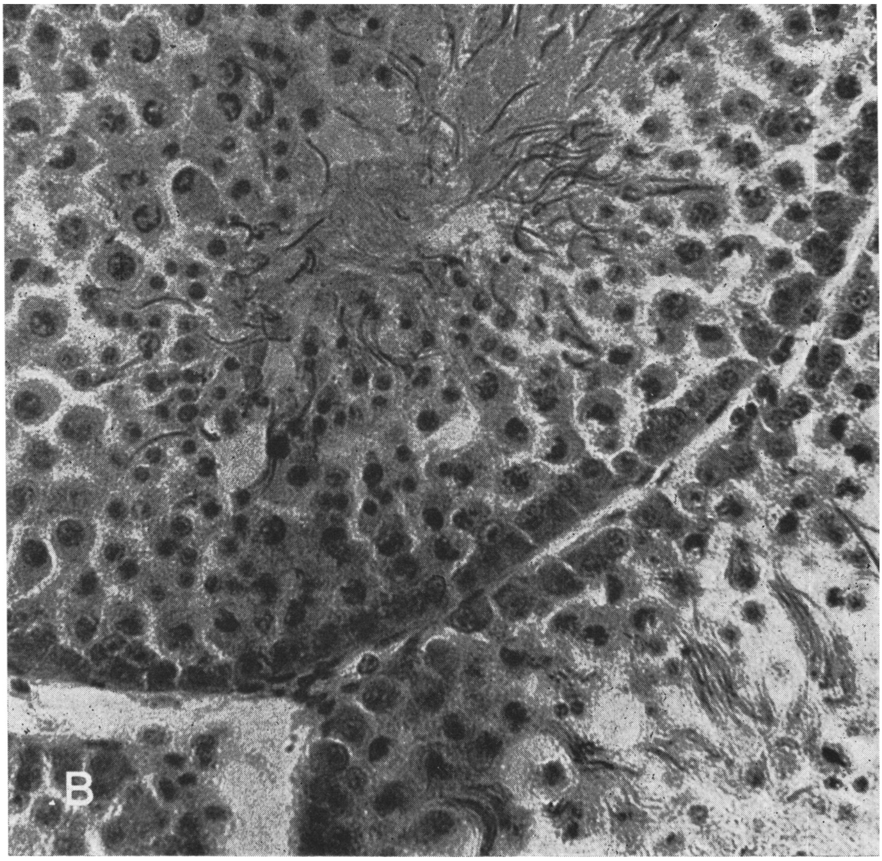

FIGURE 1B.

responsible for the multiple behavioral differences which occur in mammals as well as in avian species.

Summary. The results of this study support previous findings that Hg does reduce the reproductive potential of the female of avian species (3, 4). Additionally, the dangers of Hg are not relegated entirely to the female, but rather it is concluded that Hg exerts an equally adverse effect on the reproductive potential of the avian male. The loss of reproductive efficiency which is caused by Hg in both male and female quail may be correlated directly to a diminution in their normal mating behavior.

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