

INGESTION OF LEAD PELLETS BY SCALED QUAIL (*CALLIPEPLA squamata*) AND NORTHERN BOBWHITE (*COLINUS VIRGINIANUS*) IN SOUTHEASTERN NEW MEXICO

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ABSTRACT.—Examination of gizzards collected from 226 scaled quail (*Callipepla squamata*) and 111 northern bobwhite (*Colinus virginianus*) in 1985, 1986, and 1987, revealed that one scaled quail and two northern bobwhite had ingested lead pellets and that one northern bobwhite had ingested two steel pellets. Analyses of the livers of 155 scaled quail and 96 northern bobwhite revealed that 12 (4.8 percent) contained concentrations of lead greater than seven parts per million wet weight (range, eight to 40). There was a difference ($P < 0.05$) in lead content of livers between 1985-1986 (when lead shotshells were used to collect specimens) and 1987 (when steel shotshells were used) for scaled quail and northern bobwhite. For 1985, scaled quail taken in August contained more lead in their livers than those taken in October. Statistical comparisons among scaled quail, northern bobwhite, and mourning doves (*Zenaida macroura*) from the same study area revealed no differences in lead among species. Though there is a large amount of lead available to gamebirds in southeastern New Mexico, relatively few contained significant amounts of lead. *Key words:* lead poisoning; *Callipepla squamata*; *Colinus virginianus*; *Zenaida macroura*; New Mexico.

Ingestion of lead pellets has been reported in northern bobwhite (*Colinus virginianus*—Stoddard, 1931; Westemeier, 1966) and scaled quail (*Callipepla squamata*—Campbell, 1950). Recently, Best et al. (1992) reported on the availability of lead pellets, ingestion of lead pellets, and amounts of lead in livers of mourning doves (*Zenaida macroura*) in southeastern New Mexico. They reported concentrations of lead pellets of 167,593 to 860,185 per hectare around the stocktank they studied. Because scaled quail and northern bobwhite also occur in large numbers in southeastern New Mexico, the accumulations of lead pellets around stocktanks could cause substantial lead-poisoning losses of quail. Hunting of quail is not concentrated around stocktanks; however, quail regularly feed around stocktanks where they could pick up lead pellets that have been left by dove hunters. The purposes of this study were to determine how many lead pellets are ingested by scaled quail and northern bobwhite in southeastern New Mexico, to ascertain the concentrations of lead in the livers of these species, and to compare the amount of lead found in these species to that previously reported for mourning doves from the same study area.

MATERIALS AND METHODS

In 1985, 1986, and 1987, specimens of scaled quail (*Callipepla squamata*) and northern bobwhite (*Colinus virginianus*) were collected within a 11.2-kilometer radius of the Los Medaños Waste Isolation Pilot Plant (T. 22 S, R. 31 E, sec. 20, SE 1/4). The study area is approximately 40 kilometers east of Carlsbad, primarily in Eddy County, but it also extends into western Lea County, New Mexico. Within this 400-square kilometer study area, specimens were collected as encountered. The vegetation is dominated by shinny oak (*Quercus havardii*) and honey mesquite (*Prosopis glandulosa*), and the soils are sandy (Best and Smartt, 1985, 1986). Specimens were sexed by examination of gonads and aged using the criteria of Leopold (1939).

In 1985 and 1986, specimens were secured using lead shot and in 1987 only steel shot was used in collecting activities. Upon collection, a tag was attached to each specimen indicating time of day and precise location on the study area; later, sex, age, and weight were determined. Gizzards and livers were removed and stored in plastic bags on dry or wet ice until they could be returned to the laboratory where they were frozen.

Gizzards collected in 1985 (36 scaled quail and 10 northern bobwhite), 1986 (46 scaled quail and 22 northern bobwhite), and 1987 (144 scaled quail and 79 northern bobwhite) were dissected, the contents were sieved through a tea-strainer, the number of lead pellets in each was determined, and the lining was examined for the dark-green stain that is associated with ingestion of lead pellets (Locke and Bagley, 1967; McConnell, 1968). Pellets found in gizzards with holes in them were assumed to have entered the gizzards during collecting activities. A magnet was used to ascertain whether pellets were steel or lead; lead pellets that were difficult to distinguish from other gizzard contents (that is, seeds and rounded gravel) were scratched with a pocket knife or examined using a dissecting microscope to verify that they were lead. Livers collected in 1985 (36 scaled quail and 10 northern bobwhite), 1986 (45 scaled quail and 22 northern bobwhite), and 1987 (74 scaled quail and 64 northern bobwhite) were subjected to chemical analyses as described by Best et al. (1992).

Standard statistics (mean, range, and so on) for the number of pellets found in gizzards and the amount of lead found in livers were calculated. A one-way analysis of variance was used to assess amounts of lead in livers among samples, including comparisons with data for mourning doves.

RESULTS

Of 226 gizzards examined from scaled quail, 11 (4.8 percent) contained lead or steel pellets. All but one gizzard contained holes; a subadult female collected on 18 October 1986 contained one no. 7 1/2 or 8 lead pellet—the lining of the gizzard was not discolored.

Examination of the contents of 111 gizzards of northern bobwhite revealed that six (5.4 percent) contained lead or steel pellets. Of these, three had holes in the gizzard. The three with pellets that had been ingested (no holes in gizzard) were collected in 1987. A subadult of undetermined sex was collected on 21 August that contained one no. 7 1/2 or 8 lead pellet; the lining of the gizzard was not discolored. A subadult male was collected on 15 October that contained two no. 6 steel pellets; the lining had two black spots corresponding to the location of the pellets in the gizzard. A subadult male was collected on 19 December and contained one no. 8 or 9 round, shiny, lead pellet; the lining of the gizzard was not discolored.

There are no references in the literature to normal concentrations of lead in the livers of scaled quail and northern bobwhite; therefore, we have used the value of seven parts per million (ppm) wet weight (for mourning doves; Bagley and Locke, 1967) to indicate the normal maximum. Six (3.9 percent) of the 155 livers of scaled quail contained concentrations of lead greater than seven ppm. Three (subadult females) were collected from the same covey on 16 August 1985. The others were collected on 18 October 1986 (subadult female; subadult male) and on 26 October 1986 (subadult of undetermined sex). Concentrations of lead in their livers were 40, 8, 8, 14, 27, and 11 ppm wet weight, respectively.

Of 96 livers of northern bobwhite, six (6.3 percent) contained lead greater than seven ppm wet weight. They were collected on 16 August 1985 (subadult female), 20 October 1985 (subadult female), 23 August 1986 (subadult of undetermined sex), 22 August 1986 (subadult male), 17 October 1986 (subadult male), and 19 October 1986 (subadult female). Concentrations of lead in their livers were 12, 10, 32, 21, 12, and 16 ppm wet weight, respectively.

Various comparisons of lead concentrations in livers were made among samples using one-way analysis of variance (Table 1). There were no differences for the following comparisons ($P > 0.05$): among species (1985, 1986, 1987 combined); among species for August samples (1985, 1986, 1987 combined); among species for October samples (1985, 1986, 1987 combined); among species for December samples (1987); among months for scaled quail (1985, 1986, 1987 combined); among months for northern bobwhite (1985, 1986, 1987 combined); within years for scaled quail (1986 and 1987 separate); and within years for northern bobwhite (1985, 1986, 1987 separate).

Differences were detected between: August and October samples of scaled quail collected in 1985 (F -ratio = 10.121, $P < 0.01$); scaled quail collected with lead shot in 1985 and 1986 compared to the use of steel shot in 1987 (F -ratio = 6.832, $P < 0.05$); and northern bobwhite collected with lead shot in 1985 and 1986 compared to the use of steel shot in 1987 (F -ratio = 14.112, $P < 0.001$). Thus, the only differences ($P < 0.05$) between years appear to be related to the use of lead shot rather than steel shot to obtain specimens for analyses. Within years, the six scaled quail collected in August 1985 were different ($P < 0.01$) from the October sample. Apparently, the amount of lead ingested by scaled quail differed from August to October 1985.

An examination of data on concentrations of lead in the livers of the quail that ingested lead pellets indicates the scaled quail that contained one ingested pellet had no measurable lead in its liver. For the two northern bobwhite, both specimens had five ppm. The remaining nine quail with greater than seven ppm of lead in their livers did not contain

TABLE 1. Sample size, mean, standard deviation, and range of the lead content of livers (in parts per million wet weight) for mourning doves (*Zenaida macroura*), scaled quail (*Callipepla squamata*), and northern bobwhite (*Colinus virginianus*). *F*-ratios resulting from one-way analysis of variance are presented with an indication of statistical significance.

<i>Among species (all samples, 1985, 1986, 1987)</i>			
	Mourning dove	Scaled quail	Northern bobwhite
Sample size	250	155	96
Mean	2.488	1.019	1.344
Standard deviation	19.228	4.227	4.488
Range	0 to 257	0 to 40	0 to 32
<i>F</i> -ratio = 0.599, no significant difference among groups ($P > 0.05$)			
<i>Among species (August samples, 1985, 1986, 1987)</i>			
	Mourning dove	Scaled quail	Northern bobwhite
Sample size	178	51	38
Mean	3.303	1.314	1.895
Standard deviation	22.734	5.746	6.128
Range	0 to 257	0 to 40	0 to 32
<i>F</i> -ratio = 0.262, no significant difference among groups ($P > 0.05$)			
<i>Among species (October samples, 1985, 1986, 1987)</i>			
	Mourning dove	Scaled quail	Northern bobwhite
Sample size	66	80	44
Mean	0.515	1.063	1.182
Standard deviation	1.629	3.668	3.322
Range	0 to 9	0 to 27	0 to 16
<i>F</i> -ratio = 0.841, no significant difference among groups ($P > 0.05$)			
<i>Among species (December samples, 1987)</i>			
	Mourning dove	Scaled quail	Northern bobwhite
Sample size	6	24	14
Mean	0.000	0.250	0.357
Standard deviation	0.000	0.897	1.336
Range	0 to 0	0 to 4	0 to 5
<i>F</i> -ratio = 0.263, no significant difference among groups ($P > 0.05$)			
<i>Among months (scaled quail, 1985, 1986, 1987)</i>			
	August	October	December
Sample size	51	80	24
Mean	1.314	1.063	0.250
Standard deviation	5.746	3.668	0.897
Range	0 to 40	0 to 27	0 to 4
<i>F</i> -ratio = 0.522, no significant difference among groups ($P > 0.05$)			

TABLE I. Continued

Among months (northern bobwhite, 1985, 1986, 1987)

	August	October	December
Sample size	38	44	14
Mean	1.895	1.182	0.357
Standard deviation	6.128	3.322	1.336
Range	0 to 32	0 to 16	0 to 5

F-ratio = 0.648, no significant difference among groups ($P > 0.05$)

Within years (scaled quail, 1985)

	August	October
Sample size	6	30
Mean	9.500	0.833
Standard deviation	15.411	1.599
Range	0 to 40	0 to 7

F-ratio = 10.121, significant difference between groups ($P < 0.01$)

Within years (scaled quail, 1986)

	August	October
Sample size	20	25
Mean	0.500	2.320
Standard deviation	0.513	6.196
Range	0 to 1	0 to 27

F-ratio = 1.708, no significant difference between groups ($P > 0.05$)

Within years (scaled quail, 1987)

	August	October	December
Sample size	25	25	24
Mean	0.000	0.080	0.250
Standard deviation	0.000	0.277	0.897
Range	0 to 0	0 to 1	0 to 4

F-ratio = 1.388, no significant difference among groups ($P > 0.05$)

Within years (northern bobwhite, 1985)

	August	October
Sample size	4	6
Mean	1.500	2.500
Standard deviation	1.732	3.886
Range	0 to 3	0 to 10

F-ratio = 0.227, no significant difference between groups ($P > 0.05$)

Within years (northern bobwhite, 1986)

	August	October
Sample size	9	13
Mean	6.778	2.615
Standard deviation	11.563	5.205
Range	0 to 32	0 to 16

F-ratio = 1.321, no significant difference between groups ($P > 0.05$)

TABLE 1. Continued

<i>Within years (northern bobwhite, 1987)</i>			
	August	October	December
Sample size	25	25	14
Mean	0.200	0.120	0.357
Standard deviation	1.000	0.600	1.336
Range	0 to 5	0 to 3	0 to 5
<i>F-ratio = 0.276, no significant difference among groups ($P > 0.05$)</i>			
<i>Between lead and steel shot years (scaled quail, 1985 + 1986 and 1987)</i>			
	1985+1986 (lead)	1987 (steel)	
Sample size	81	74	
Mean	1.852	0.108	
Standard deviation	5.714	0.538	
Range	0 to 40	0 to 4	
<i>F-ratio = 6.832, significant difference between groups ($P < 0.05$)</i>			
<i>Between lead and steel shot years (northern bobwhite, 1985 + 1986 and 1987)</i>			
	1985+1986 (lead)	1987 (steel)	
Sample size	32	64	
Mean	3.625	0.203	
Standard deviation	7.201	0.946	
Range	0 to 32	0 to 5	
<i>F-ratio = 14.112, significant difference between groups ($P < 0.001$)</i>			

lead pellets in their gizzard. The northern bobwhite with two steel pellets in its gizzard had no measurable lead in its liver.

DISCUSSION

The presence of lead pellets in the gizzards of dead birds often has been believed to be a reliable indicator of lead poisoning, but death actually is caused by lead that has been dissolved, transformed into lead salts, and absorbed into the body (Friend, 1985).

A scaled quail described by Campbell (1950) showed no evidence of disease or starvation, but the gizzard contained 13 lead pellets of various sizes ranging from about no. 8 to no. 4. McConnell (1968) studied lead poisoning of northern bobwhite and found that the first signs of lead poisoning appeared about five days following ingestion of pellets. Only 10 percent of the quail died. Dead quail had lost 36 percent of their original body weight, had full crops, and their gizzard linings were roughened and stained dark-green to dark-brown. He also observed that northern bobwhite readily ingested lead pellets from soil in their cages. Stoddard (1931) reported that one pellet in the gizzard is sufficient to cause death from lead poisoning among penned northern bobwhite up to 41 days of age and that one adult died with two lead pellets in its

gizzard. He believed that mortality of quail from ingested pellets could reach significant proportions, on intensively hunted areas, without being noticed. In southeastern New Mexico, the incidence of lead pellets in the gizzards of scaled quail and northern bobwhite is greater than that for mourning doves, though all are at a relatively low frequency.

For scaled quail, 3.9 percent contained concentrations of lead greater than seven ppm wet weight. Those with lead concentrations of three ppm or greater represent 6.5 percent (10 of 155) of the sample. For northern bobwhite, 6.3 percent contained concentrations of lead greater than seven ppm wet weight. Those with lead concentrations of three ppm or greater represent 14.6 percent (14 of 96) of our sample.

It is of interest to note that ingestion of lead pellets may have effects other than increased mortality among post-fledgling gamebirds. Buerger et al. (1986) found that ingestion of one no. 8 lead pellet by female mourning doves caused a reduction in hatchability of their eggs, but did not influence productivity or fertility. Decreased hatchability resulted from higher early embryonic mortality, possibly due to the transfer of lead from the adult to the embryo via the egg. Edens and Garlich (1983) compared chickens and quail in a reproductive study and concluded that quail were more susceptible to lead than chickens. Stone and Soars (1974) reported that Japanese quail (*Coturnix japonica*) that ingested lead produced more soft-shelled eggs than controls. In ringed turtle-doves (*Streptopelia risoria*), testes weights were lower in lead-treated males and spermatozoan numbers tended to be lower (Kendall and Scanlon, 1981).

Ingestion of lead pellets is not the only potential source of lead poisoning for gamebirds in southeastern New Mexico. Exposure to lead may be compounded further when gamebirds feed on roadside grit particles, because there are considerably higher lead levels near roads with high traffic densities (see Kendall and Scanlon, 1979). Another possibility is ingestion of lead with drinking water (Best et al., 1992). Because of the ease of ingestion and assimilation into body tissues of lead taken in with drinking water, the problem may be more serious than indicated by the number of lead pellets recovered from gizzards or lead concentrations in livers.

Poisoning by ingestion of lead pellets can cause death in waterfowl (Bellrose, 1959). Based on observations of upland species, they are also susceptible to poisoning by ingestion of lead pellets (Stoddard, 1931; Campbell, 1950; Hunter and Rosen, 1965; Westemeier, 1966; Locke and Bagley, 1967; Artmann and Martin, 1975; Stone and Butkas, 1978). There are huge numbers of lead pellets available for ingestion by various species of birds in southeastern New Mexico (Best et al., 1992) and decomposing lead pellets may serve as a source of lead in drinking water. Because sick and dying birds may seek shelter in rodent burrows, are captured and consumed by predators, or otherwise are not easily

observed, it is difficult to assess the numbers of birds that are killed each year by lead poisoning. It is equally difficult to assess what the long-term effect will be. The numbers of lead pellets that will continue to become available by erosion and exposure of buried pellets or new deposition by hunters may affect populations of various species of birds for years.

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