

## The incidence of ingested lead shot in ducks of the Evros Delta, Greece

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Lead poisoning of waterfowl through the ingestion of spent gunshot has long been recognised in the USA, where it is to be banned for all waterfowl hunting by 1991. Recent research in the Camargue suggests that in European wetlands this problem may be at least as serious. This paper presents the results of the first such study to have been conducted in Greece, in the Evros Delta. A high incidence of shot ingestion was recorded in the gizzards of hunter-shot waterfowl, particularly in Pochards (a diving duck) and Pintail, Mallard and Teal (dabbling ducks).

The susceptibility of waterfowl to shot ingestion has been recognised for more than a century (Grinnel 1894). Considerable research into lead poisoning has been carried out in the United States of America over the last 50 years. The magnitude of the problem both for waterfowl (of which 1.6-2.4 million are estimated to die annually in the USA alone; USFWS 1986) and raptors which predate or scavenge sick or dead waterfowl has led to federal legislation banning the use of lead shot for all waterfowl and Coot *Fulica atra* hunting in the USA by 1991 (USFWS 1986). Lead is being replaced by non-toxic steel. Although wildfowling is equally widespread in most European countries, relatively few investigations have been carried out, particularly in southern Europe, where hunting pressure is high. However, recent research in the Camargue (southern France) has shown that the incidence of shot ingestion by many species is higher than has been recorded elsewhere (Piroit & Taxis 1987, Pain 1990a). It has been suggested that those waterfowl that feed in areas lacking naturally available grit, such as river deltas, may be particularly susceptible to shot ingestion (Piroit & Taxis 1987). In Europe, important wintering sites for waterfowl are found in ecologically similar areas (e.g. Rhone Delta, France; Evros Delta, Greece; Ebro Delta, Spain; Po Delta, Italy etc.) many of which are listed as 'Wetlands of International Importance espe-

cially as Waterfowl Habitat' under the Ramsar Convention. The recent results from the Camargue and increasing concern over lead poisoning led to the initiation of a study in the Evros Delta, the most important of Greece's 11 Ramsar sites in terms of diversity and numbers of wintering waterfowl.

### The Study Area

The Evros Delta, the easternmost Greek wetland (40°47'N, 26°05'E), is on the frontier with Turkey. The Greek part of the delta covered an area of approximately 150 km<sup>2</sup> of undisturbed wetland 40 years ago, although, as a result of agricultural development, only 50% of this remains today. Approximately half of the remaining area is protected, the rest being open to hunting. Despite considerable human pressure, the lagoon and fresh/brackish water lakes of the delta provide a wintering site for an average of 73,000 waterfowl (50-200,000; Athanasiou 1987), more than one third of the average total wintering waterfowl counts for Greece (Handrinos 1989). Hunting takes place mainly in the eastern part of the delta between 15 September and 10 March every year. For this purpose, approximately 175 huts have been constructed (Forestry Department pers. comm.), each of which can cater for an average of four hunters. These huts are used by hunters from all over Greece and, in addition, many locals enter the delta on a daily basis. It is likely that this pressure has led to a high density of shot in the sediments.

### Methods

During January 1989 and 1990, hunting huts in the Evros Delta (Fig. 1) were visited and gizzards collected from ducks shot by hunters.

Gizzards were cut in half and the contents washed into a dish with a water jet. The gizzard lining was carefully inspected for the presence of shot entry holes. Plant material was examined

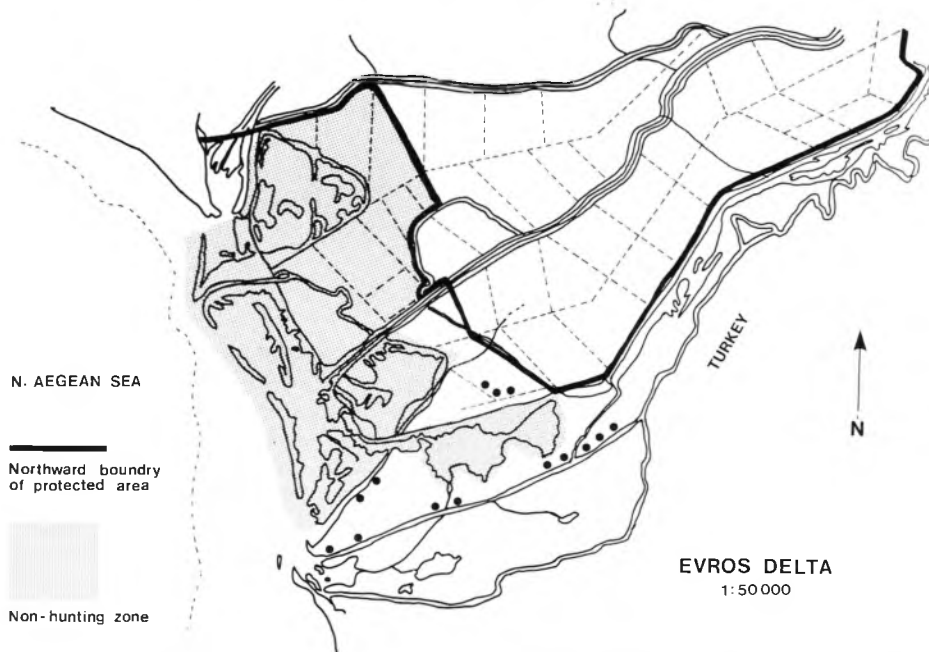


Figure 1. The Evros Delta between Greece and Turkey showing (as dots) the concentration of hunters' huts.

manually for grit and shot and removed by flotation. The remaining material was spread out thinly in a dish and examined using a binocular microscope (x4-x16). All material resembling lead was scratched with a scalpel for verification (lead is soft and easily cut revealing a shiny grey-silver surface). The presence of pellets which may have been 'shot-in' was noted (large grey shot with flattened uneroded surfaces). A positive result was recorded only for those samples containing shot that had obviously been ingested.

**Results**

One hundred gizzards were collected, 55 in 1989 and 45 in 1990. Ingested shot was found in all diving and dabbling species except Shoveler *Anas clypeata* in both 1989 and 1990 (Table 1), with the highest incidence of shot ingestion in diving duck. No shot was found in Wigeon *Anas penelope* or Gadwall *A. strepera*, which are primarily grazing species. In 52% of the gizzards found to contain ingested shot, only one shot was found. Five or more were found in 14% of cases. Three percent of samples contained shot considered to have entered with the charge that killed the bird. Grit was found in all gizzards; in diving and dabbling species a range of grit sizes was present, while grazing species contained exclusively sand.

Table 1. Incidence of ingested lead shot in the gizzards of waterfowl from the Evros Delta.

	Sample size <i>n</i>	With ingested shot <i>n</i>	% shot ingestion for each class
<b>Diving ducks</b>			
<i>Aythya ferina</i>	14	7	53
<i>Aythya fuligula</i>	1	1	
<b>Dabbling ducks</b>			
<i>Anas acuta</i>	8	4	
<i>Anas platyrhynchos</i>	11	4	21
<i>Anas clypeata</i>	9	0	
<i>Anas crecca</i>	34	5	
<b>Grazing ducks</b>			
<i>Anas strepera</i>	15	0	
<i>Anas penelope</i>	7	0	0
<i>Netta rufina</i>	1	0	

**Discussion**

Site and species specific data on the incidence of lead ingestion by waterfowl have been collected traditionally by examining the gizzards of birds killed by hunters (Bellrose 1959, Mudge 1983, Sanderson & Bellrose 1986).

In the USA, the only country to have legislated against the use of lead, the average inci-

dence of shot ingestion in (hunter-shot) diving ducks ranges from 12 to 24% (Sanderson & Bellrose 1986). In comparison with these already high ingestion levels, those found in the Evros Delta (53% for diving ducks) are extremely elevated, and comparable with those recently recorded in the Camargue (60%; Pain 1990a).

In our study, marked interspecific differences in the incidence of shot ingestion were found (Table 1). These results reflect those of all previous investigations (reviewed in Pain 1990b), with diving duck more susceptible to ingestion than dabblers, and little shot ingested by grazing species. These differences are probably related to feeding method, and the preferred size of grit. There is considerable interspecific variation in the grit ingested. Diving duck tend to take fairly large grit, of similar diameter to shot (c.2-3 mm), whereas grazing species ingest mainly sand (<1 mm) (Pain 1990a and this study). It has been suggested that the very high incidence of shot ingestion recently found in the Camargue may be related to the absence of naturally available grit, and the presence of high shot densities in the delta's sediments (Pirot & Taris 1987). Such an explanation may also be valid for the Evros Delta and many of the other European wetlands important for wintering waterfowl.

It is likely that in areas with a high incidence of shot ingestion by waterfowl, other birds, in particular raptors, are also at risk (USFWS 1986). The Evros Delta is one of the few remaining places where the Sea Eagle *Haliaeetus albicilla* breeds in Greece and is also an important wintering area for the Spotted Eagle *Aquila clanga* (Halindros 1987). Both of these species feed largely upon sick and injured waterfowl and their populations have become severely diminished over the last century (Bijlevend 1974, Cramp *et al.* 1980). The Lesser White-fronted Goose *Anser erythropus* and Red-breasted Goose *Branta ruficollis*, both threatened on a world scale, can also be found wintering in the delta and the endangered Slender-billed Curlew *Numenius tenuirostris* passes through on migration to and from its wintering grounds (Goutner & Handrinos 1990).

The results of this study and those recently carried out in the Camargue (Pain 1990a) and in other countries such as Britain (Mudge 1983) show that lead poisoning may present a serious threat to waterfowl and possibly other birds of European wetlands. At present data are lacking for all other wetlands in southern Europe. It is important that co-ordinated research into the problem be carried out to establish its significance for all species at risk, many of which already have declining populations.

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