Why are lead-poisoned waterfowl rarely seen?: the disappearance of waterfowl carcasses in the Camargue, France.

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This study investigates the longevity of waterfowl carcasses in a typical wetland habitat in the Camargue, France. With a high carcass density (50 birds in 7.8 ha) scavenging rates were very rapid. Carcasses in exposed positions on land persisted for on average 1.5 days, those concealed by vegetation for 3.3 days and those exposed on water for 7.6 days. These differences are probably related to the identity and abundance of predators and scavengers and their foraging routes.

The results indicate that high lead poisoning waterfowl mortality may occur unnoticed by hunters and game managers in the Camargue and other similar wetlands, mainly due to elevated rates of carcass removal by scavengers and predators.

Lead poisoning of waterfowl and other birds, through the ingestion of spent gunshot has long been recognised as a mortality factor (Grinnell 1894, Calvert 1876). Most lead poisoning research has been carried out in the USA and it has been estimated that approximately 2-3% of the autumn waterfowl population (1.6-2.4 million birds) in the USA die from the direct results of lead poisoning annually (Bellrose 1959, USFWS 1986).

Raptors are also susceptible to lead poisoning following ingestion of shot in the flesh of their prey and in the USA, 250 Bald Eagles *Haliaeetus leucocephalus*, an endangered species, have died from lead poisoning (M. Friend, pers. comm.).

Concern over avian lead poisoning mortality in the USA has resulted in the passing of legislation banning the use of lead shot for all waterfowl and coot hunting in the USA by this (1991-92) hunting season (USFWS 1986). With the exception of Denmark, no action has been taken elsewhere.

Lead poisoning research in Europe remained relatively low-key until the last decade. However, the results of recent research have shown average levels of shot ingestion by waterfowl in Northern Europe to be similar to USA averages. In Mediterranean wetlands, many of which are heavily hunted, these levels are much higher (Table 1).

Most lead poisoning research in the Mediterranean has been carried out in the Camargue (Rhone river delta). The Camargue is an important area for wintering waterfowl with average January counts of duck and coot (1980-86 average) of 104,500 (maximum 192,200) (Tamisier, cited in Duncan 1988).

The elevated shot ingestion levels by waterfowl recorded in the Camargue (Pain 1990) and elsewhere in the Mediterranean (Pain & Handrinos 1990) potentially result in high waterfowl mortality. However, there are relatively few reports of waterfowl found dead or dying of lead poisoning in these areas, and hunters often remark that they have never noticed lead poisoning casualties. Both the nature of lead poisoning, and rapid removal of sick and dead birds

Table 1. Average incidence of shot ingestion in waterfowl (% of hunter killed birds with 1 or more shot in alimentary tract).

	USA (1973-1984)	Northern Europe	Mediterranean
Herbiverous/ grazing duck	1.0	1.1	3.3
Dabbling duck	8.5	3.7	21.5
Diving duck	17.4	19.7	59.5
Sample *n*	168523	10890	1925

by predators and scavengers probably explain this. Lead poisoned birds classically move away from the flock and crawl into thick vegetation or 'escape cover' at the waters edge for protection, thus decreasing their visibility. The behaviour of lead poisoned birds, particularly their staggering gait and inability to hold up their wings, may result in their misidentification as hunting cripples, and hunters dogs may occasionally remove poisoned birds. However, the most important factor precluding the observation of lead poisoned birds is probably the rapid removal of sick and dead birds by predators and scavengers. In the USA, experimental studies have shown rapid scavenging rates of waterfowl carcasses placed in typical wetland habitat (Stutzenbaker *et al.* 1986). However, it has frequently been argued that the rapid scavenging rates found in American studies might not apply in Europe where a different set of scavengers and predators are present.

This study investigates the length of time that waterfowl carcasses persist in typical Mediterranean wetland habitat in the Camargue, France.

Methods

The study was carried out at The Station Biologique de la Tour du Valat (43°31'N, 4°40'E) in the Camargue. The Tour du Valat covers 2062 hectares of the Parc Naturel Regional and consists mainly of natural and semi-natural habitats which serve for the conservation of biodiversity, ecological research and agricultural and pastoral production.

The area chosen for the study was a marsh of 7.8 hectares comprising a range of different vegetation, one large semi-permanent water body and several small water bodies (Fig. 1). The area was not free from disturbance as agricultural land adjoined the area from the north and east.

The methodology was chosen to resemble that of American studies (Stutzenbaker *et al.* 1986) for comparative purposes. However, a far higher density of carcasses was placed in our study (7.7 carcasses per hectare compared with 1.2 per hectare).

On 19 September 1990, 60 fresh Mallard *Anas platyrhynchos* carcasses (30 male, 30 female) were placed in three different situations as follows:

10 birds were placed in open water

25 birds were placed on open ground in exposed positions

25 birds were placed under vegetation, completely concealed from view (this simulates the

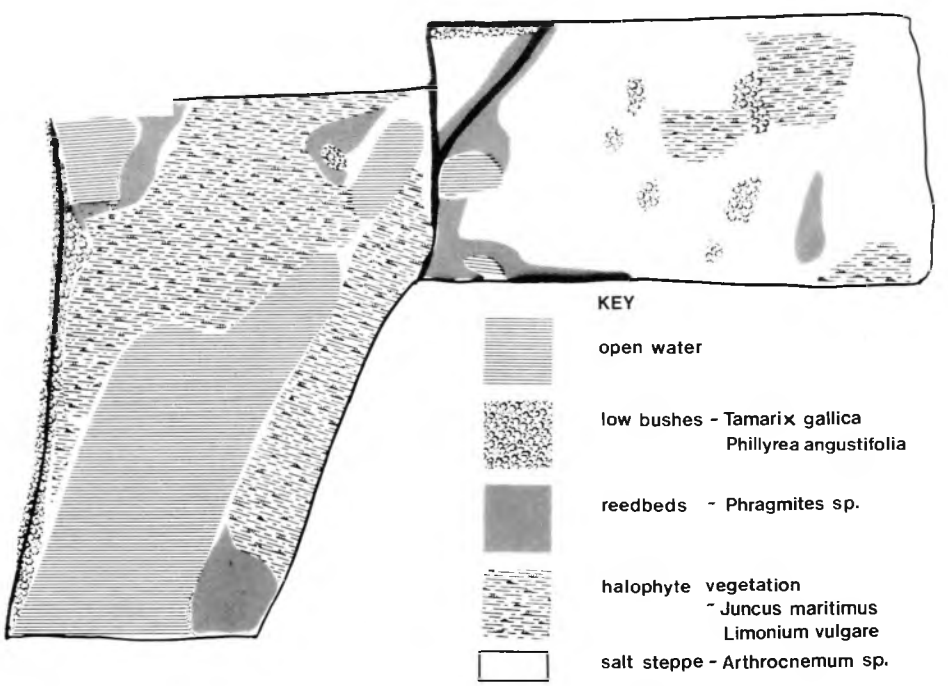

Figure 1. General vegetation cover of the experimental site covering approximately 7.8 ha.

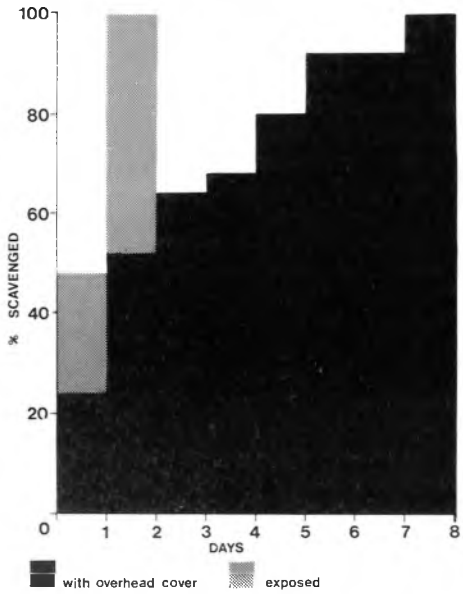

Figure 2. The rates in days during which waterfowl carcasses placed on land (exposed or concealed) were completely scavenged (i.e. removed or only feathers/ bones remaining).

escape cover commonly used by lead poisoned birds).

Half males and half females were used in each case. The position of each carcass was precisely marked on a map and a numbered *Phragmites* cane (*c.* 1 m high) was placed approximately 2 m away from the carcass to facilitate identification. Carcasses placed in open water were attached to a *Phragmites* cane by a 1.5 m long cord to prevent drifting to the bank. Each site was visited once daily between 12:00 and 14:00 (as predator/scavenger activity is generally low during this period) and the condition and position of each carcass noted. The degree of scavenging was scored as follows:

1 - carcass completely removed
2 - only bones and feathers remaining
3 ->50% scavenged, e.g. flesh remaining on neck, legs etc.
4 - 20-50% scavenged
5 - <20% scavenged
6 - untouched

The experiment was terminated when all carcasses had reached stages 1 or 2.

Results

Rates of scavenging of carcasses were extremely rapid, as is illustrated in Figure 2 and Table 2. Carcass longevity was significantly lower for exposed carcasses on land than for concealed carcasses (T-test, t = 4.00, $P<0.001$, df = 26.6), and significantly higher for carcasses in the water than on land (T-test, t = 3.99, $P<0.002$, df = 12.8 for concealed carcasses; t = 6.17, $P<0.001$, df = 9.2 for exposed carcasses). Table 2 compares the longevity of carcasses in our study with those of a similar study carried out in the USA. In general, carcass removal rates were higher in our study than in the American study, in spite of higher carcass densities. One interesting difference is that carcasses with overhead cover persisted longer in this study than in the American study, where they disappeared more rapidly than those in completely exposed positions. The longevity of carcasses in different positions, and differences between the results of the two studies, is probably related to both the identity and abundance of predators and scavengers, and their foraging routes.

Although the scavengers were not identified in our study, several types of scavenging were recorded.

Carcasses concealed by vegetation or exposed were either removed entirely and hidden nearby, removed and eaten nearby (>5 m from original placement with bones and/or feathers remaining), or removed with no trace. Half (48%) of the exposed carcasses on land had

Table 2. Average longevity of waterfowl carcasses in the Camargue (this study) and on the Texas coast (Stutzenbaker *et al.* 1986).

Density birds/ha	Average longevity (days) With overhead cover	Carcasses exposed	Carcasses restrained in open water
Texas coast			
1.21	2.6	3.8	11.2
n	20	21	6
Camargue			
7.70	males 3.54 \ 3.32 / females 3.08	males 1.45 \ 1.52 / females 1.57	7.6
n	25	25	10

been completely scavenged within 24 hours. Of the 13 that remained, more than half appeared to have been scavenged by birds within 24 hours, with only breast meat removed. Carcasses placed on open water were often scavenged in a similar way before being removed by larger animals. Scavenging rates of exposed carcasses were significantly higher for those placed in the northeastern half of the site (without the water body) (mean longevity of 1.17 days compared with 1.85 days, T-test, t = 4.43, $P<0.001$, df = 22.7). This difference is again probably related to specific foraging routes of scavengers and predators. There were no differences between longevity of male and female Mallard carcasses.

Animals regularly seen in the area at this time of year that may have acted as scavengers include:

Larus argentatus - Herring Gull
Circus aeruginosus - Marsh Harrier
Corvidae - Jackdaws, Magpies etc.
Vulpes vulpes - fox
Sus scrofa L. - wild boar
Mustela putorius L. - polecat.

The density and species composition of avian scavengers was fairly low during the period of the study. Far higher densities are present during the summer months, particularly *Milvus* sp., and winter months, particularly *Circus* sp.

Discussion

The longevity of waterfowl carcasses in this study was very low. This experiment was carried out in a typical Mediterranean wetland, with a moderate amount of human disturbance, and at a time of year when densities of certain (particularly avian) scavengers were not at their highest. However, as the area is not open to hunters, the density of scavengers may have been higher than in hunted areas. The scavengers/predators present in the Camargue are widespread throughout Europe. The rapid removal of carcasses in this study is, therefore, unlikely to be unique.

Although the main scavengers in this study were not identified, the results suggest that several different types of scavengers, both avian and mammal, were responsible for carcass deterioration and removal. As Marsh Harriers were likely to have been one of the scavengers of exposed birds in this study, it is worth mentioning that predation or scavenging of waterfowl that carry shot in their flesh (i.e. unretrieved or crippled game) can present a problem for raptors (although they are less likely to ingest shot that are carried in the intestines of lead poisoned waterfowl). Although there is no published work in Europe directly concerning lead poisoning of raptors, lead shot have been incidentally recorded in the pellets of Marsh Harriers in France (Bavoux *et al.* 1990), and other species of raptors have been reported as dying from lead poisoning.

The 'invisibility' of waterfowl that have died from lead poisoning or other non-hunting causes has been illustrated in several American studies. Studies aimed at documenting non-hunting waterfowl losses have shown the difficulty of finding intact waterfowl carcasses. Intensive hunts have revealed mainly feather piles, wings and bones or partially eaten carcasses. In one such study, only 22.4% (934 of 4165) of waterfowl carcasses found were intact, and scavenging activity was found to be the most important factor precluding the documentation of total losses (Humberg *et al.* 1983). In experimental studies, in which wild ducks have been fed lead shot and released carrying radio transmitters, the location of sick and dead ducks was very difficult and time consuming. One of the reasons was that carcasses were often buried in thick vegetation and could only be located following extensive searching with telemetry equipment (Krystofik *et al.* 1986). The difficulty of finding sick and dead birds, even when searching specifically for them, has also been illustrated by Stutzenbaker *et al.* (1986), who placed 100 waterfowl carcasses in a 40 hectare area, half exposed on top of vegetation and half concealed in typical 'escape cover'. An 8 man search crew was sent to look for sick and dead birds half an hour after carcass placement. None of the carcasses concealed by vegetation and only six (12%) of those in exposed positions were found.

Waterfowl mortality, from lead poisoning or other causes, is only likely to become conspicuous when numbers of birds dying exceed the capacity of predators and scavengers to remove them. Lead poisoning mortality generally results in continual, day to day losses of small numbers of waterfowl. In this experiment, the mean longevity of waterfowl carcasses on land was 2.4 days, and 3.3 days for birds in typical escape cover. Considering the maximum wintering waterfowl populations in the Camargue and the area available to them, it would appear that an extremely high level of waterfowl mortality would be necessary to exceed the capacity of predators and scavengers to remove dead birds. This is true even assuming that in our study predators were attracted to the study area

away from normal foraging routes due to superabundance of food, and assuming that waterfowl in the Camargue are concentrated in a relatively small area.

The results of this study indicate that high lead poisoning waterfowl mortality may occur unnoticed by hunters and game managers in the Camargue and other similar wetlands, mainly due to the rapid removal of carcasses by scavengers and predators.

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