EXCERPTS FROM THE ABSTRACTS OF THE XV INTERNATIONAL ORNITHOLOGICAL CONGRESS (held at The Hague 30 August-3 September 1970)

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Symposium on Birds and Man: the Mounting Threat of Chemical Pollution

J. A. KEITH–Pesticide Section, Canadian Wildlife Service

Residue levels of chemical pollutants in North American birdlife

Residues of organochlorines have been the most commonly reported, and very recently attention has been paid to heavy metals. Among organochlorines, the long-known insecticide metabolite DDE, and the recently identified PCB's of industrial origin, are found in widely ranging amounts in virtually all specimens examined. Generally, the highest residue levels of both occur in birds that eat other birds or fish, or that feed on marine plankton. Among heavy metals, mercury is now being established as a pollutant of both terrestrial and aquatic birds, with highest levels in raptors preying on grain-eating animals, or in birds that eat fish. Relationships between residues in birds and suspected sites of chemical use are very tenuous for organochlorines and more direct for mercury. The very recent reports of residues of PCB's and mercury do not reflect new uses, these chemicals have probably been significant pollutants of birdlife for several deacdes.

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The avifauna of Sweden and the environmental contamination with organomercurials with a note on the presence of chlorinated hydrocarbons.

In Sweden elaborate studies have been made on the contamination of the natural environment with mercury. In terrestrial habitats the use of alkyl-mercury compounds was responsible for a serious contamination of different wildlife species. The analysis of feathers of birds of prey turned out to be a sensitive detection system to discover the type of application which caused the contamination of wildlife. Analyses of feathers of goshawks from museum collections clearly demonstrated that a sudden increase in the mercury levels occurred in 1940. In that year alkyl-mercury compounds were introduced as seed dressing materials in Sweden.

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Metabolism of foreign compounds by different classes of birds

The determination of biological halflife and the metabolic patterns of drugs, toxicants or model compounds are well known aspects of detoxication studies in mammals and insects, but rarely undertaken in birds. From experiments with mammalian liver preparations in vitro it became clear that many xenobiotic compounds are metabolized by the smooth-surfaced microsomes and by the cytoplasmatic enzymes, yielding as a rule more water-soluble substances. Most studies however were performed with the familiar laboratory species (rats, mice, rabbits). These biochemical investigations are supported by an impressive body of knowledge of the structures and ultrastructures of mammalian tissues.

Some results will be presented with respect to the drug enzymes in kestrel livers and the occurrence of enzymic glutathione conjugations in wild bird livers with foreign compounds as precursors of mercapturic acids. A short discussion is given of the ability of birds to deal with foreign compounds and of the possible role of the natural diet. During these studies we were struck by the many gaps in background information, both biochemical and cytological. It follows that caution must be exercised when employing methods proven in mammalian studies in other animal classes.

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Effects of polychlorinated biphenyls on birds

Toxicities of six commercial preparations of polychlorinated biphenyls (PCB's) were studied on penned mallards (*Anas platyrhynchos*), pheasants (*Phasianus colchicus*), bobwhite (*Colinus virginianus*) and Japanese quail (*Coturnix coturnix*) at the Patuxent Wildlife Research Center near Laurel, Maryland. LC_{50}'s, expressed as p.p.m. of PCB in dry feed, were determined for the Aroclor

(Registered name, Monsanto Company) "compounds" 1232, 1242, 1248, 1254, 1260, and 1262 on 2-week-old birds fed treated diets for 5 days. Aroclor toxicity, generally less than that of DDT, was found to be directly related to increased chlorine percentage (last two digits of Aroclor number). Low dietary levels (25 and 50 p.p.m.) of Aroclor 1254 are evaluated in 2-year reproductive studies on mallards and bobwhite.

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Effects of Organochlorine insecticides on European birdlife

Contamination of terrestrial, freshwater and marine birds in Europe by persistent organochlorine insecticides is widespread. In densely populated countries with intensive agriculture it may be universal. Many wilderness species are seasonally at risk to contamination because they migrate and predators can obtain residues from prey migrating from areas with insecticide use.

There appear to be differences in effects of organochlorine residues between species, probably because of a combination of differential exposure according to varying habitat and differential response according to interspecific physiological and behavioural differences.

Sub-lethal effects appear to be mainly on reproduction. These cause reduced success in some species, mainly raptors, and follow a characteristic syndrome involving decreased eggshell thickness, parental egg-breakage, reduced output of young and finally an apparent inability to lay eggs. Other species with decreased shell thickness and egg-breakage still fledge young because they lay repeat clutches which are successful. In many species the residues apparently have no obvious effects. Reproductive failure, if severe enough, can eventually cause population decline.

Lethal poisoning of birds has followed the release of organochlorines into lakes and rivers in industrial and agricultural effluents, heavy local applications, and their use in spring as a seed-dressing. Relatively large amounts can pass along food chains to predatory species which in turn may be killed. There is no evidence of permanent effects on populations of granivorous species, but several terminal predators have shown spectacular declines apparently due to exceptional mortality caused by organochlorine poisoning.

Restrictions on organochlorine insecticide use has reduced lethal poisoning, improved breeding success and been followed by a partial recovery of raptor populations. Conservation of European birds is thus linked with future use of organochlorine insecticides.

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Eggshell changes in certain North American birds

Museum data, field correlations, and controlled experiments all confirm D. A. Ratcliffe's hypothesis that certain raptor population crashes of the past two decades are characterized by historically unprecedented changes in eggshell thickness and weight that in turn have led to egg breakage, disappearance, and egg eating. The unique change began in 1947 on a wide-scale basis in peregrine falcons (*Falco peregrinus*) in eastern North America as well as Europe and extended to fish-eating birds and other raptors. These recent changes in eggshells vary geographically within a given species and, at least locally, between populations and in some cases between individuals. Often they vary from one year to the next. Although many factors may affect eggshells in birds, the remarkable phenomenon of widespread eggshell change proves to be consistently associated with DDE levels in laying females and their eggs; relations between residues of other chemical pollutants remain to be carried out. Some of the eggshell changes, while statistically significant, are not having an obvious and critical effect at the population level. Obvious reproductive failures appear to be correlated with a mean decrease on the order of greater than 20 per cent. in shell thickness and weight. Among the species that appear to be suffering population effects, either locally or regionally, as a result of this DDT pollution are: (1) regionally to widespread, Peregrine Falcon; (2) locally to regionally, Brown Pelican (*Pelecanus occidentalis*), Double-crested Cormorant (*Phalacrocorax auritus*), Cooper's Hawk (*Accipiter cooperi*), Bald Eagle (*Haliaeetus leucocephalus*), Osprey (*Pandion haliaetus*), Black-crowned Night Heron (*Nycticorax nycticorax*); (3) locally, March Hawk (*Circus cyaneus*), Prairie Falcon (*Falco mexicanus*), Herring Gull (*Larus argentatus*). Eggshell changes of a minor nature are evident in: Common Loon (*Gavia immer*), White Pelican (*Pelecanus erythrorhynchos*), Rough-legged Hawk (*Buteo lagopus*), Red-tailed Hawk (*B. jamaicensis*), Red-shouldered Hawk (*B. lineatus*), Broad-winged Hawk (*B. platypterus*), Golden Eagle (*Aquila chrysaetos*), Sparrow Hawk (*Falco sparverius*), Great Blue Heron (*Ardea herodias*), Great Horned Owl (*Bubo virginianus*), Common Crow (*Corvus brachyrhynchos*).