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ORGANOCHLORINE PESTICIDES, PCBs AND MERCURY IN HAWK, FALCON, EAGLE AND OWL EGGS FROM THE LIPETSK, VORONEZH, NOVGOROD AND SARATOV REGIONS, RUSSIA, 1992–1993

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ABSTRACT.—Fifty-two eggs (one per nest) of 12 species of raptors were collected in 1992–93 for contaminant analysis in three southern European locations in Russia. One Peregrine Falcon (*Falco peregrinus*) egg was also collected farther northwest in the Novgorod region. A high DDE concentration (27.3 ppm, wet weight [w/w]) in the Peregrine Falcon egg raised concern for the species in European Russia south of the Arctic Circle. Although a number of organochlorine contaminants were found in eggs of the other species, concentrations were all below known effect levels. Mercury levels were also extremely low. Nesting success in southern Russia in 1992 (only year with follow-up visits) appeared normal.

KEY WORDS: *Peregrine Falcon;* Falco peregrinus; *eagles; hawks; falcons; owls; organochlorine pesticides; PCBs; mercury; Russia.*

Pesticidas organoclorados, PCBs y mercurio en huevos de gavilanes, halcones, águilas y buhos de las regiones de Lipetsk, Voronezh, Novgorod y Saratova en Rusia, 1992–93

RESUMEN.—Cincuenta y dos huevos (uno por nido) de 12 especies de aves rapaces fueron colectados en 1992–93 para el análisis de contaminantes en tres localidades al sur de Europa en Rusia. Un huevo de Halcón Peregrino (*Falco peregrinus*) fue colectado al noroeste en la región de Novgorod. Una alta concentración de DDE (27.3 ppm), en este huevo despertó preocupación para la especie en la Rusia europea al sur del Círculo Artico. Aunque un buen número de contaminantes organoclorados fueron encontrados en los huevos de otras especies, las concentraciones estuvieron por debajo de niveles peligrosos. Los niveles de Mercurio fueron también extremadamante bajos. El éxito reproductivo en 1992 (único año en el que se efectuó seguimiento) aparentemente fué normal.

[Traducción de César Márquez]

Concerns over possible pesticide contamination of raptors in Russia were first raised in the 1970s (Galushin 1977), an alarm first sounded by the rapid and continuous decline of the Peregrine Falcon (*Falco peregrinus*). To assess the extent of chemical contamination in Russian birds of prey, a series of egg collections were made. Eggs of the Peregrine Falcon were specifically collected above the Arctic Circle on the Kola Peninsula in 1991 (Henny et al. 1994). Osprey (*Pandion haliaetus*) eggs were collected along the Upper Volga River in 1992. This paper is the third in a series that presents the results of contaminant analyses conducted on eggs of species collected in southern European Russia in 1992 and 1993.

STUDY AREA AND METHODS

In 1992, 13 eggs (one egg per clutch) were collected from the Lipetsk Region which includes the Upper Don River. This study area was located 30 km east of Elets Town and 40 km west of Lipetsk City near the Galichya Gora Nature Reserve. The Liptsk Region is mostly agricultural (fall and spring planted wheat, small grains, peas, and row crops) with some natural forests. Another 13 eggs were collected in the Voronezh Region about 300 km east and south of the Lipetsk Region. It consists of agricultural lands separated by planted forest strips. This study area was 10 km south of Talovaya or 120 km southeast of Voronezh City. Raptors nested in planted forest strips. Tree planting began 100 yr ago and has continued for the purpose of stopping wind erosion of top soils. Crops were mainly small grains, corn, peas, sunflowers, and other row crops with some fields irrigated. One egg was an addled Peregrine Falcon egg taken in the more northwestern Novgorod Region. There were no nestlings in this nest but a fledgling was observed nearby.

In 1993, another 26 eggs were collected southeast of Saratov at the middle Volga River located south and east of the 1992 study areas. Habitat included forest-steppe and steppe. Nests where eggs were collected in 1992 were subsequently observed by local biologists to determine nest productivity. Nests where eggs were collected in the Saratov Region in 1993 could not be monitored.

ANALYTICAL AND STATISTICAL METHODS

The collected eggs were opened in Russia and their contents were placed in chemically cleaned jars containing Na_2SO_4 for preservation. Egg contents were analyzed at the Geochemical and Environmental Research Group, Texas A&M University, College Station, Texas. Egg samples for organics were extracted by the NOAA Status and Trends Method (MacLeod et al. 1985) with minor revisions (Brooks et al. 1989; Wade et al. 1988). Briefly, the egg samples were homogenized with a Teckmar Tissumizer. A 1–10 g sample w/w was extracted with the Teckmar Tissumizer by adding surrogate standards, Na_2SO_4 and methylene chloride in a centrifuge tube. The tissue extracts were purified by silica/alumina column chromatography to isolate the aliphatic and PAH/pesticide/PCB fractions. The pesticide/PCB fraction was further purified by HPLC in order to remove interfering lipids. Eggs were analyzed for alpha-hexachlorocyclohexane (A-BHC), β-BHC, Δ-BHC, lindane, hexachlorobenzene (HCB), heptachlor, heptachlor epoxide (HE), oxychlordane, gamma chlordane, alpha chlordane, *trans*-nonachlor, *cis*-nonachlor, aldrin, dieldrin, endrin, mirex, p,p′-DDE (DDE), p,p′-DDT (DDT), p,p′-DDD (DDD), o,p′-DDE, o,p′-DDT, o,p′-DDD, and total PCBs. The quantitative analyses were performed by capillary gas chromatography (GC) with electron capture detection for pesticides and PCBs. Total PCBs were quantified by summing the concentrations of homolog groups which were estimated by degree of chlorination (Wade et al. 1988). The pesticides and PCBs are initially analyzed on a DB-5 capillary column. The analyte identity and concentrations are confirmed on a DB-17 capillary column. We also analyzed for 87 PCB congeners in 1993, but the concentrations were so low in almost all species that congener data were only discussed for the Peregrine Falcon egg analyzed (species with the highest PCB concentrations). A comparison of estimated total PCBs vs. sum of PCB congeners showed excellent agreement between the two procedures for individual eggs with the highest PCB concentrations.

Mercury was determined by EPA method 245.5 with minor revisions. Tissue samples were homogenized in the original sample containers with a tissumizer and subsampled. Mercury was determined by a modification of the method of Hatch and Ott (1968). A portion of the digest solution was placed in a sealed container. To this was added 0.4 ml of 10% (w/w) stannous chloride. Mercury was reduced to the elemental state and aerated from solution into an atomic absorption spectrophotometer where its concentration was measured.

Residue concentrations in eggs were corrected to an approximate fresh w/w using egg volumes (Stickel et al. 1973); all organochlorines and mercury in eggs were expressed on a fresh w/w basis. The detection limit was considerably below 0.01 ppm w/w, but from a biological perspective, values were not presented unless ≥0.01 ppm.

The General Linear Models Procedures (SAS 1996) was used to perform a one-way analysis of variance. Residue data were $\log_{10}$ transformed for all analyses and means were presented as geometric means, and $\alpha = 0.05$ for statistical significance.

RESULTS

In general, raptors common to the southern portion of European Russia are found in woodlands, forest-strips, forest-steppe, isolated groves, semi-open and open steppes (Table 1). Segments of the steppe are now farmed, and many of the buzzards, kestrels, falcons, harriers, goshawks, kites, and owls nest in close association with agriculture. We considered all species to be migratory in at least portions of their range and, therefore, could accumulate contaminants on wintering grounds which sometimes are great distances from nesting areas. Only eggs collected in 1992 were analyzed for mercury so the mercury results were presented separately.

Buzzards. DDE, β-BHC and PCBs were found in nearly every buzzard egg (Tables 2 and 3). Common Buzzards (*Buteo buteo*) from both agricultural areas contained low and not statistically different DDE concentrations (geometric mean [$\bar{x}$] = 0.15 and 0.20 ppm). Likewise, concentrations of DDE in Long-legged Buzzard (*Buteo rufinus*) eggs (0.13 ppm) from the native steppe were not significantly different from those of the Common Buzzard.

β-BHC (0.01 and 0.02 ppm) and PCBs (0.06 and 0.22 ppm) were low in Common Buzzard eggs from both agricultural sites. When β-BHC and PCBs in Common Buzzard eggs were combined for the two sites (β-BHC = 0.02 and PCBs = 0.13 ppm) and compared to Long-legged Buzzards, β-BHC was significantly higher in eggs of the Long-legged Buzzard ($P = 0.01$), but PCBs were not significantly different. The highest PCB concentration was 2.20 ppm in a Common Buzzard egg from the Lipetsk Region.

Harriers. Five Montagu's Harrier (*Circus pygargus*) eggs from Voronezh contained 0.45 ppm DDE which was not significantly different from the 0.18

Table 1. General characteristics of birds of prey studied in European Russia, 1992–93.[a]

SPECIES	HABITAT	MIGRATORY	WINTER AREAS
Long-legged Buzzard	Steppe, semidesert	Yes	E. Africa, S. Asia
Common Buzzard	Mixed	Yes	Africa, S. Europe
Imperial Eagle	Woodland, forest-steppe	Yes	N.E. Africa, S.W. Asia
Steppe Eagle	Steppe, semiopen	Yes	India, S. Africa
Booted Eagle	Thinly wooded	Yes	Africa, S. Asia
Common Kestrel	Groves, semiopen	Yes	Africa, India, S. Europe
Red-footed Falcon	Groves, mixed	Yes	S. Africa
Peregrine Falcon[b]	Woodland, semiopen	Partly	S. and C. Europe
Montagu's Harrier	Open	Yes	Africa, S. Asia
Black Kite	Floodplains, water	Yes	Africa, S. Asia
Northern Goshawk	Forest, woodland	Partly	S. and C. Europe
Long-eared Owl	Woodland, thickets	Partly	S. and C. Europe

[a] Information obtained from Amadon et al. (1988), Cramp (1980), Dementev et al. (1966), Ilychev (1982).
[b] Those nesting below 60°N latitude.

ppm DDE found in Common Buzzard eggs from Voronezh and Lipetsk. β-BHC ($\bar{x}$ = 0.02 ppm) and PCBs ($\bar{x}$ = 0.05 ppm) were found in low concentrations in all Montagu's Harrier eggs from Voronezh and, when compared to buzzard eggs from Voronezh and Lipetsk combined (β-BHC 0.02 and PCBs 0.13 ppm), there was no significant difference between the two species. As with the buzzards, DDD and DDT were sometimes detected at low concentrations in the harrier eggs. Dieldrin and oxychlordane were regularly found in the harrier eggs but at low concentrations and low concentrations of heptachlor epoxide were reported in four of five harrier eggs but not in the buzzard eggs.

Falcons. The Common Kestrel (*Falco tinnunculus*) was found in all three study areas so it gave the first opportunity to make a broad comparison of residue concentrations in one species. We found no statistically significant differences in the low DDE concentrations between Voronezh (0.03 ppm), Lipetsk (0.06 ppm), or Saratov (0.03 ppm). DDD and DDT were not detected in any kestrel eggs. PCB concentrations in kestrel eggs at Voronezh (0.02 ppm) and Lipetsk (0.05 ppm) were not significantly different, but when the two areas were combined and compared to kestrels in Saratov (0.02 ppm), the small difference was statistically significant (P = 0.01). HCB appeared in low concentrations in one egg from Lipetsk and two eggs from Saratov. The two Red-footed Falcon (*Falco vespertinus*) eggs from Saratov contained DDE, β-BHC, and PCB concentrations that were nearly identical to the kestrels from the same region.

Common Buzzard eggs contained significantly higher concentrations of DDE (0.18 ppm) than kestrel eggs (0.05 ppm) (P = 0.01), significantly higher concentrations of PCBs (0.13 vs. 0.04 ppm) than kestrel eggs ($P < 0.05$), but β-BHC (0.02 vs. 0.01 ppm) was not significantly different. A comparison of Montagu's Harrier eggs from Voronezh with kestrel eggs from Voronezh and Lipetsk combined showed DDE was significantly higher in the harrier eggs (0.45 vs. 0.05 ppm) ($P < 0.002$), while β-BHC and PCBs were not significantly different.

The Peregrine Falcon egg from the Novgorod Region contained much higher concentrations of nearly all contaminants (Table 3). Despite the fact that 27.3 ppm DDE was the highest concentration of a contaminant found in any egg collected, one young fledged from the nest. On 15 July 1993 near the same Peregrine Falcon nest, two fledglings were observed with two adults. In 1994, the nest was not visited but, on 30 May 1995, three nestlings and a pipping egg were observed in the nest. This nest site was the only one found in a bog on the ground within a forest zone of European Russia. PCBs and HCB levels were also higher than in any other eggs and DDD, DDT, dieldrin, HE, lindane mirex, *trans*-nonachlor and oxychlordane were also present. The eggshell thickness was 0.316 mm.

The Peregrine Falcon egg was analyzed for 87 PCB congeners of which almost half were reported at concentrations above 0.01 ppm. PCB congeners (IUPAC Numbers) including PCB 138 (2.44 ppm), PCB 153 (4.93 ppm) and PCB 180 (1.59 ppm) were dominant and accounted for 61% of the 14.6 ppm. Other PCB congeners with >0.20 ppm were PCB 74 (0.23 ppm), PCB 194 (0.24 ppm), PCB 196

(0.25 ppm), PCB 128 (0.26 ppm), PCB 170 (0.29 ppm), PCB 172 (0.36 ppm), PCB 183 (0.43 ppm), PCB 146 (0.54 ppm), PCB 156/171/202 (0.54 ppm), PCB 187/182/159 (0.66 ppm), and PCB 118/108/149 (0.96 ppm). This list of congeners accounted for 13.72 ppm, or 94% of the PCBs in the Peregrine Falcon egg. The estimated total PCB concentrations, using a different methodology on the same egg, was nearly identical (14.3 vs. 14.6 ppm) (Table 3).

Eagles. Seven eagle eggs were collected and the Booted Eagle (*Hieraaetus pennatus*) egg contained the highest DDE concentration (1.06 ppm) with some DDD and DDT; the Imperial Eagle (*Aquila heliaca*) egg was intermediate with 0.33 ppm DDE and some DDD and DDT; and the five Steppe Eagle (*Aquila rapax*) eggs were lowest (0.05 ppm) with no DDD or DDT. The list of other contaminants found in the eagle eggs was fairly long, including α-BHC and Δ-BHC in the Steppe Eagle.

Steppe Eagle and Common Kestrel eggs from Saratov were compared. DDE concentrations were not significantly different, but Steppe Eagles contained significantly higher concentrations of both β-BHC (0.28 vs. 0.02 ppm, $P = 0.0001$) and PCBs (0.03 vs. 0.02 ppm, $P < 0.001$).

Goshawks and Kites. Two Northern Goshawk (*Accipiter gentilis*) eggs from Voronezh and Lipetsk contained nearly identical DDE residue concentrations (1.14 and 1.37 ppm) which were higher than reported for all eggs collected except for one Montagu's Harrier (1.48 ppm) and the Peregrine Falcon (27.3 ppm) eggs. DDD, DDT, β-BHC and PCBs were also found in the goshawk eggs. Black Kite (*Milvus migrans*) eggs from Lipetsk and Saratov contained very similar concentrations of DDE (0.38 to 0.54 ppm), in addition to DDD and DDT, and low concentrations of several others.

Long-eared Owl. The Long-eared Owl (*Asio otus*) egg from Saratov contained extremely low concentrations of DDE, PCBs and HCB.

Mercury Residues in Eggs. No eggs contained mercury concentrations above 0.05 ppm, which is an extremely low concentration (Table 2). All Common Buzzard eggs contained mercury, but showed no significant difference between Voronezh and Lipetsk. Only one of eight kestrel and none of the Northern Goshawk nor Montagu's Harrier eggs had detectable mercury concentrations from either Voronezh or Lipetsk. The Black Kite and Booted Eagle eggs also contained low concentrations of mercury. The Saratov eggs were not analyzed for mercury.

Table 2. Organochlorine pesticides, PCBs, and mercury (ppm, wet weight) in birds of prey eggs (number of eggs in parentheses) from Voronezh and Lipetsk Regions, Russia, 1992.

SPECIES LOCATION (N)[a]	CLUTCH SIZE (N)[b]	YOUNG FLEDGED (N)[c]
Common Buzzard		
Voronezh (4)	3.50(2)	2.33(3)
Range	3–4	2–3
Lipetsk (5)	3.25(4)	1.75(4)
Range	2–4	1–3
Northern Goshawk		
Voronezh (1)[f]	4.00(1)	2.00(1)
Lipetsk (1)	3.00(1)	1.00(1)
Common Kestrel		
Voronezh (3)	5.33(3)	3.00(3)
Range	5–6	0–5
Lipetsk (5)[f]	5.80(5)	3.00(5)
Range	4–7	0–5
Montagu's Harrier		
Voronezh (5)[g]	4.75(4)	2.40(5)
Range	4–5	0–4
Black Kite		
Lipetsk (1)	3.00(1)	2.00(1)
Booted Eagle		
Lipetsk (1)[g]	2.00(1)	1.00(1)

[a] Number of eggs analyzed for contaminants.
[b] Mean includes egg collected for residue analysis, but excludes nests with fresh eggs (possibly incomplete clutches).
[c] Young fledged value excluded from mean calculation if lone egg collected from nest. Note that 1 egg was collected from each nest.
[d] Geometric mean used for residue concentrations (0.005 ppm assigned to values <0.01 ppm) since no value presented <0.01; e.g., = none detection (ND). No mean calculated if ≥50% of samples <0.01 ppm.
[e] HG = mercury, DDE = p,p'-DDE, DDD = p,p'-DDD, DDT = p,p'-DDT, β-BHC = beta-hexachlorocyclohexane, PCBs = polychlorinated biphenyls, OXY = oxychlordane, HE = heptachlor epoxide.
[f] Goshawk from Voronezh and 1 kestrel from Lipetsk each contained 0.01 ppm hexachlorobenzene.
[g] Two Montagu's Harriers and the Booted Eagle each contained 0.01 ppm *trans*-nonachlor.

DISCUSSION AND CONCLUSIONS

The Peregrine Falcon egg collected in 1992 from the Novgorod Region (south of St. Peters-

Table 2. Extended.

Geometric Mean (ppm)[d]								
HG[e]	DDE[e]	DDD[e]	DDT[e]	β-BHC[e]	PCBs[e]	OXY[e]	Dieldrin	HE[e]
0.03	0.15	—	—	0.01	0.06	—	—	—
0.02–0.05	0.03–0.30	ND–0.02	ND	0.01–0.05	0.04–0.10	ND	ND–0.10	ND
0.04	0.20	—	—	0.02	0.22	—	—	—
0.03–0.05	0.06–0.59	ND–0.04	ND–0.01	ND–0.09	0.07–2.70	ND	ND–0.01	ND
ND	1.14	0.07	0.16	0.08	0.26	ND	ND	ND
ND	1.37	0.06	0.01	0.04	0.41	ND	ND	ND
—	0.03	—	—	0.01	0.02	—	—	—
ND	0.01–0.11	ND	ND	0.01	0.02–0.03	ND	ND	ND
—	0.06	—	—	0.01	0.05	—	—	—
ND–0.01	0.03–0.21	ND	ND	0.01–0.02	0.01–0.16	ND	ND	ND
—	0.45	—	—	0.02	0.05	0.01	0.02	0.02
ND	0.17–1.48	ND–0.01	ND–0.04	0.01–0.07	0.02–0.12	ND–0.02	ND–0.05	ND–0.10
0.03	0.45	0.05	0.01	0.05	0.20	ND	0.03	ND
0.02	1.06	0.03	0.01	0.04	0.31	0.02	0.01	0.02

burg) with 27.3 ppm DDE causes us the most concern. This bog-associated site was successful in 1992, 1993, and 1995 but we are not sure if the same female occupied the site each year. The DDE concentration in the egg was much higher than the mean of 3.5 ppm w/w reported for the increasing Peregrine Falcon population nesting along the Ponoy Depression (above 66°N) of the Kola Peninsula, Russia in 1991 (Henny et al. 1994). The fact that young were produced at this nest in 1992 gives reason for some optimism. Peakall et al. (1975) tentatively concluded that 15–20 ppm DDE w/w was associated with the inability of Peregrine Falcons to maintain population numbers. Ambrose et al. (1988) believed that 15–20 ppm DDE should not be construed so rigidly as to predict the success or failure of individual eggs, and believed that a gradual reduction in productivity occurs above a DDE level that is not precisely known. In fact, they reported young were fledged from five of six nests in Alaska where randomly-sampled fresh eggs contained over 15 ppm DDE. Even though the critical concentration for DDE is not precisely known, 27.3 ppm DDE found in the egg from this study provides a serious reason for continued concern for Peregrine Falcons in the more southern latitudes of European Russia. The shell thickness of the egg collected was 0.316 mm, which represents only 10% shell thinning compared to 0.350 mm for pre-DDT era Swedish Peregrine Falcons (Lindberg 1975). Pesticides were never used during breeding seasons within the bog-associated hunting area of that Peregrine Falcon pair we studied. Few peregrines exist in European Russia south of the Arctic Circle, and their specific migration routes and wintering areas remain unknown.

DDE in the eggs of the other species were much lower with values seldom above 1 ppm. Since a difference exists in sensitivity among species to DDE, it is difficult to reach conclusions about its potential effects on the various species we studied. However, two of the most sensitive species to DDE are

Table 3. Organochlorine pesticides and PCBs (ppm, wet weight) in birds of prey eggs from the Sarotov Region, 1993 and one egg from Novgorod Region, Russia, 1992.

SPECIES (N)[a]	CLUTCH SIZE (N)[b]	GEOMETRIC MEAN (ppm)[c]				
		DDE[d]	DDD[d]	DDT[d]	β-BHC[d]	PCBs[d]
Common Kestrel (12)	4.80(5)	0.03	—	—	0.02	0.02
Range	3–6	0.01–0.07	ND	ND	0.01–0.06	0.01–0.03
Steppe Eagle (5)	2.80(5)	0.05	—	—	0.28	0.03
Range	2–3	0.03–0.11	ND	ND	0.13–0.52	0.03–0.04
Red-footed Falcon (2)	—	0.03	—	—	0.01	0.02
Range	—	0.03–0.04	ND	ND	0.01	0.02
Long-legged Buzzard (3)	2.50(2)	0.13	—	—	0.11	0.14
Range	2–3	0.07–0.26	ND	ND	0.07–0.26	0.08–0.36
Black Kite (2)	2.00(2)	0.45	0.06	0.05	0.33	0.09
Range	2	0.38–0.54	0.06	0.03–0.08	0.27–0.41	0.08–0.10
Imperial Eagle (1)	2.00(1)	0.33	0.25	0.05	0.35	0.10
Long-eared Owl (1)	4.00(1)	0.07	ND	ND	ND	0.04
Peregrine Falcon Novgorod (1)[e]	—	27.3	0.28	0.09	0.17	14.3

[a] Number of eggs analyzed for contaminants.

[b] Mean includes egg collected for residue analysis, but excludes nests with fresh eggs (possibly incomplete clutches).

[c] Geometric mean used for residue concentrations (0.005 ppm assigned to values <0.01 ppm) since no value presented <0.01 ppm; i.e., = nondetected (ND). No mean calculated if ≥50% of samples <0.01 ppm.

[d] DDE = p,p'-DDE; DDD = p,p'-DDD; DDT = p,p'-DDT; β-BHC, A-BHC, Δ-BHC=beta, alpha and delta hexachlorocyclohexane; PCBs = polychlorinated biphenyls; HCB = hexachlorobenzene; HE = heptachlor epoxide; OXY = oxychlordane.

[e] Also contained mirex 0.01 ppm, o,p'-DDT 0.02 ppm, and *trans*-nonachlor 0.01 ppm.

the Brown Pelican (*Pelecanus occidentalis*) (nearly total reproductive failure at 3.0 ppm w/w in eggs), and the White-faced Ibis (*Plegadis chihi*) (reduced reproductive success above 4 ppm w/w in eggs) (Blus 1982, Henny and Herron 1989). With the highest DDE egg concentrations <2 ppm, it is doubtful that DDE had an adverse effect on any of the other species. Furthermore, the number of young produced in 1992 appeared normal (e.g., six of eight nests [75%] with fresh or slightly incubated eggs at time of collection successful; 15 of 16 nests [94%] with medium-heavy incubation successful with fledging young).

Effects of specific concentrations of other organochlorines are not well understood, and again sensitivity undoubtably differs among species. HE above 1.5 ppm w/w in American Kestrel (*Falco sparverius*) eggs resulted in reduced production (Henny et al. 1983), but Canada Geese (*Branta canadensis*) showed no sign of reduced hatchability until egg residues were above 10 ppm w/w (Blus et al. 1984). Henny et al. (1983) found no negative impact on productivity of American Kestrels when dieldrin in eggs ranged from 2.2–3.9 ppm w/w. None of the HE or dieldrin concentrations reported during this study approached the above levels, therefore, it is extremely doubtful that HE or dieldrin were adversely impacting the species studied. Concentrations of all the other organochlorine pesticides were extremely low. PCBs were seldom reported above 0.50 ppm and the buzzard nest with the highest PCB egg concentration (2.7 ppm) had four eggs with one egg collected, and fledged the maximum of three young. The only other high concentration of PCBs was in the Peregrine Falcon egg.

Mercury concentrations in eggs were <0.05 ppm, which is lower than the geometric mean of 0.09 ppm w/w for Ospreys on the Upper Volga River in 1992. Mercury concentrations in eggs below 0.5–0.6 ppm w/w do not adversely affect raptor reproduction (Häkkinen and Häsänen 1980, Wiemeyer et al. 1984, Newton and Haas 1988).

A-BHC, Δ-BHC, lindane, HCB, DDT and its metabolites, the chlordanes, and PCBs which were found in many of the eggs were also found in the blubber of a resident seal (*Phoca caspica*) from the coast of Iran on the Caspian Sea (Vetter et al. 1995). The Caspian Sea has no connection to the oceans and is south of the Saratov study area, and bordered by Russia, Kazakhstan, Turkmenistan, Iran and Azerbaijan. The resident seal which can-

Table 3. Extended.

Geometric Mean (ppm)[c]						
A-BHC[d]	Δ-BHC[d]	Dieldrin	Lindane	HCB[d]	HE[d]	OXY[d]
—	—	—	—	—	—	—
ND	ND	ND	ND	ND–0.09	ND	ND
0.01	0.01	0.01	—	—	—	—
ND–0.02	ND-0.01	ND–0.03	ND	ND-0.01	ND	ND
—	—	—	—	—	—	—
ND	ND	ND	ND	ND	ND	ND
—	—	—	—	0.01	—	—
ND	ND	ND–0.06	ND	0.01	ND	ND–0.01
—	—	—	—	0.01	—	—
ND–0.08	ND–0.02	ND–0.01	ND–0.03	0.01	ND–0.09	ND–0.02
0.04	0.03	ND	0.01	0.01	0.01	0.01
ND	ND	ND	ND	0.08	ND	ND
ND	ND	0.18	0.01	1.16	0.12	0.12

not migrate, therefore, provides some evidence that many of the contaminants found in the raptor eggs could be accumulated in the region where they nested. Species sharing breeding localities sometimes contained different contaminants, which may be a function of different wintering localities or food habits. Our data are too fragmentary to discuss contaminant residue patterns in eggs with respect to the species migratory characteristics or wintering ranges and food habits.

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LITERATURE CITED

AMADON, D., J. BULL, J.T. MARSHALL AND B.F. KING. 1988. Hawks and owls of the world: a distributional and taxonomic list. *Proc. West. Found. Vertebr. Zool.* 3:295–357.

AMBROSE, R.E., C.J. HENNY, R.E. HUNTER AND J.A. CRAWFORD. 1988. Organochlorines in Alaskan Peregrine Falcon eggs and their current impact on productivity. Pages 385–393 *in* T.J. Cade, J.H. Enderson, C.G. Thelander and C.M. White [EDS.], Peregrine Falcon populations: their management and recovery. The Peregrine Fund, Inc., Boise, ID U.S.A.

BLUS, L.J. 1982. Further interpretation of the relation of organochlorine residues in Brown Pelican eggs to reproductive success. *Environ. Pollut.* 28:15–33.

———, C.J. HENNY, D.J. LENHART AND T.E. KAISER. 1984. Effects of heptachlor- and lindane-treated seed on Canada Geese. *J. Wildl. Manage.* 48:1097–1111.

BROOKS, J.M., T.L WADE, E.L. ATLAS, M.C. KENNICUTT II, B.J. PRESLEY, R.R. FAY, E.N. POWELL AND G. WOLFF. 1989. Analysis of bivalves and sediments for organic chemicals and trace elements. Third Annual Report for NOAA's National Status and Trends Program. Contract 50-DGNC-5-00262.

CRAMP, S. [ED.]. 1980. Handbook of the birds of Europe, the Middle East and North Africa: the birds of the western Palearctic. Oxford Univ. Press, Oxford, U.K.

DEMENTEV, G.P., N.A. GLADKOV, E.S. PTUSHENKO, E.P. SPANGENBERG AND A.M. SUDILOVSKAYA. 1966. Birds of the Soviet Union, Vol. 1. Israel Program Scientific Translations, Jerusalem, Israel. (Translated from Russian).

GALUSHIN, V.M. 1977. Recent changes in the actual and legislative status of birds of prey in the U.S.S.R. Pages 152–159 *in* Proc. World Conference on Birds of Prey, Vienna 1975. ICBP, London, U.K.

HÄKKINEN, I. AND E. HÄSÄNEN. 1980. Mercury in eggs and nestlings of the Osprey (*Pandion haliaetus*) in Finland and its bioaccumulation from fish. *Ann. Zool. Fenn.* 17: 131–139.

HATCH, W.R. AND W.L. OTT. 1968. Determination of submicrogram quantities of mercury in solution by a flameless atomic absorption technique. *Anal. Chem.* 40:2085–2087.

HENNY, C.J. AND G.B. HERRON. 1989. DDE, selenium, mercury and White-faced Ibis reproduction at Carson Lake, Nevada. *J. Wildl. Manage.* 53:1032–1045.

———, L.J. BLUS AND C.J. STAFFORD. 1983. Effects of heptachlor on American Kestrels in the Columbia Basin, Oregon. *J. Wildl. Manage.* 47:1080–1087.

———, S.A. GANUSEVICH, F.P. WARD AND T.R. SCHWARTZ. 1994. Organochlorine pesticides, chlorinated dioxins and furans, and PCBs in Peregrine Falcon *Falco peregrinus* eggs from the Kola Peninsula, Russia. Pages 739–749 *in* B.-U Meyburg and R.D. Chancellor [EDS.], Raptor Conservation Today. Pica Press, London, U.K.

ILYCHEV, V. D. 1982. Migrations of birds of eastern Europe and northern Asia: Falconiformes–Gruiformes. Nanka Publishing House, Moscow, Russia.

LINDBERG, P. 1975. Pilgrimsfalken i Sverige. Svenska Naturskyddsföreningen, Stockholm, Sweden.

MACLEOD, W.D., D.W. BROWN, A.J. FRIEDMAN, D.G. BURROW, O. MAYES, R.W. PEARCE, C.A. WIGREN AND R.G. BOGAR. 1985. Standard analytical procedures of the NOAA National Analytical Facility 1985–1986. Extractable Toxic Organic Compounds. 2nd Ed. U.S. Department of Commerce, NOAA/NMFS, NOAA Tech. Memo. NMFS/NWRC-92.

NEWTON, I. AND M.B. HAAS. 1988. Pollutants and Merlin eggs and their effects on breeding. *Br. Birds* 81:258–269.

PEAKALL, D.B., T.J. CADE, C.M. WHITE AND J.R. HAUGH. 1975. Organochlorine residues in Alaskan peregrines. *Pestic. Monit. J.* 8:255–260.

SAS INSTITUTE, INC. 1996. SAS user's guide: statistics. Version 6.12. Ed. SAS Institute, Inc., Cary, NC U.S.A.

STICKEL, L.F., S.N. WIEMEYER AND L.J. BLUS. 1973. Pesticide residues in eggs of wild birds: adjustment for loss of moisture and lipid. *Bull. Environ. Contam. Toxicol.* 9· 193–196.

VETTER, W., C. NATZECK, B. LUCKAS, G. HEIDEMANN, B. KIABI AND M. KARAMI. 1995. Chlorinated hydrocarbons in the blubber of a seal (*Phoca caspica*) from the Caspian Sea. *Chemosphere* 30:1685–1696.

WADE, T.L., E.L. ATLAS, J.M. BROOKS, M.C. KENNICUTT II, R.G. FOX, J. SERICANO, B. GARCIA AND D. DEFREITAS. 1988. NOAA Gulf of Mexico status and trends program: trace organic contaminant distribution in sediments and oyster. Estuaries II, 171–179.

WIEMEYER, S.N., T.G. LAMONT, C.M. BUNCK, C.R. SINDELAR, F.J. GRAMLICH, J.D. FRASER AND M.A. BYRD. 1984. Organochlorine pesticide, polychlorobiphenyl, and mercury residues in Bald Eagle eggs—1969–79—and their relationships to shell thinning and reproduction. *Arch. Environ. Contam. Toxicol.* 13:529–549.

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