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Timing and Location of Wing Molt in Horned, Red-necked and Western Grebes in North America

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Abstract.—We document timing and location of wing molt in the Horned Grebe (*Podiceps auritus*), Red-necked Grebe (*Podiceps grisegena*), and Western Grebe (*Aechmophorus occidentalis*). Horned Grebes left breeding ponds in late May to August and were observed on large ponds and lakes (near breeding locations) where they replaced remiges before progressing to wintering areas in September and October. Red-necked Grebes moved to much larger bodies of water such as the Great Lakes and the coast following breeding and prior to molt. On the Pacific Coast, Boundary Bay, British Columbia was identified as a major molt site. Freshwater molting areas were identified around Manitoulin Island in northern Lake Huron. On the Atlantic coast, molt sites were located in the Gulf of St. Lawrence. Western Grebes were found in wing molt at both large freshwater lakes and coastal locations (including Boundary Bay, British Columbia). Like the Great Crested Grebe (*P. cristatus*) and Eared Grebe (*P. nigricollis*), Horned, Red-necked and Western Grebes move to special molt locations following breeding. Received 20 June 2002, accepted 12 October 2002.

Key words.—*Aechmophorus occidentalis*, Horned Grebe, molt, *Podiceps auritus*, *Podiceps grisegena*, Red-necked Grebe, Western Grebe.

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Flight-feather molt in birds is of interest because it affects mobility, which, in turn, impacts ability to obtain food and evade predators. Several groups of birds (Gaviidae, Podicipedidae, Pelecanoididae, Anseriformes, Gruidae, Rallidae, Heliornithidae, Anhingidae, Phoenicopteridae, Jacanidae, Alcidae, and Bucerotidae) replace old flight feathers simultaneously (Stresemann and Stresemann 1966). In grebes (Podicipedidae), duration of molt and replacement has been estimated at 17 days in the Great Crested Grebe (*Podiceps cristatus*); (Piersma 1988) and 35 days in the Eared Grebe (*P. nigricollis*), with most growth completed in 20 days (Storer and Jehl 1985; Jehl 1990). Molt of the remiges in grebes typically coincides with the prebasic body molt.

The Great Crested Grebe and Eared Grebe have well documented molt migrations. The largest concentration of Great Crested Grebes occurs on the IJsselmeer, a large freshwater lake in The Netherlands, where 40,000-80,000 birds undergo molt in late summer and autumn (Piersma 1987). In North America, the Eared Grebe has the largest aggregations of molting individuals known for any bird, gathering at hypersaline lakes (Jehl 1990). Aggregations of this spe-

cies number nearly two million birds at Mono Lake, California (Boyd and Jehl 1998).

There is little information on wing-molt locations for other grebe species. The purpose of this paper is to review and extend information on wing-molt timing and locations for three species of grebes in North America—Horned Grebe (*Podiceps auritus*, known as Slavonian Grebe in Europe), Red-necked Grebe (*Podiceps grisegena*), and Western Grebe (*Aechmophorus occidentalis*)—and to compare their molt strategies with those of better-studied grebes.

METHODS

We reviewed data on the phenology and location of molt in relation to breeding, breeding site departure, migration, and arrival at wintering areas for Horned, Red-necked and Western Grebes in North America. We identified grebes with recently molted or partially grown remiges by observing wing-flapping individuals (Piersma 1987) at breeding and post-breeding locations. Finally, we examined banding data and observations of grebes in Alaska contributed by James G. King to link their banding locations with post-breeding aggregations of grebes and to find possible evidence of molt site fidelity.

Molt status, breeding phenology and breeding-site departure data for Horned and Red-necked Grebes were obtained on the Yellowknife Study Area (YKSA) near Yellowknife, Northwest Territories (62°27'N,

114°22'W) in 1998-2000. The YKSA (described in Fournier and Hines 1999) is a 38-km² roadside area containing numerous ponds within a zone of open subarctic woodland. Grebes were banded and color-marked with a unique combination of colored leg bands for identification throughout the breeding season. Focal pairs were surveyed one to three times per week until their departure.

Bird Studies Canada (BSC) volunteers, conducted monthly or twice-monthly shore-based waterbird surveys along the southeastern shores of Semiahmoo and Boundary Bays in coastal southwest British Columbia, from 1994-2000. Additionally, occasional September-October surveys and observations of grebes in Boundary Bay, including visits to the western shore, were conducted in 1997-2000.

Shore-based and aerial surveys in southeastern Lake Superior and eastern Lake Huron were conducted in August through early October of 1993-1995, as part of a study of Red-necked Grebe migration through the Great Lakes region. Shore-based surveys were also conducted around the southern Gulf of Saint Lawrence from 19 to 23 September 1994, with stops at 52 locations (Stout 1995).

Horned Grebe banding data were obtained from the Canadian Wildlife Service Bird Banding Office. Details of banding in Alaska were provided by James King, who organized waterfowl banding near Tetlin, Alaska (63°10'N, 142°30'W) in July and August of 1956-1961, and in the Yukon Flats National Wildlife Refuge (66°10-50'N, 142-147°W) in July and August of 1960-1966. Waterfowl were driven into large funnel traps (King 1963) and grebes were captured incidentally.

RESULTS

Horned Grebe

From specimen records (mainly Eurasian), Fjelds  (1973) found Horned Grebes in wing molt in August through October as part of the prebasic molt that began in June. In Scotland, Horned Grebes moved to large lakes after breeding to complete the prebasic molt (Summers and Mavor 1995). In

North America, a few Horned Grebes with growing remiges have been reported in July and August in Alaska and interior British Columbia (Stedman 2000).

Adult Horned Grebes depart breeding ponds from late May to late August, with most leaving in July (Riske 1976; Ferguson 1977; Fournier and Hines 1999; this study), but wintering sites are reached "in regular numbers" by mid-late October or later (Stedman 2000), suggesting a two to three month gap between average departure from breeding ponds and arrival at wintering locations.

In 1998, 1999, and 2000 at YKSA, nesting color-marked Horned Grebes under regular observation (N = 179 adults, 21 of which were followed for two years) showed no evidence of wing molt while on the breeding ponds. In July and August, adult Horned Grebes appeared on large ponds (>15 ha, 1-3 m deep, and not used for breeding). Four adults captured on these ponds on 23-24 August 1999 had attained 90% of basic plumage. Two of these had a full set of completely grown new remiges and in two all remiges were about 90% grown. Fournier and Hines (1999) also noted small groups of adult Horned Grebes in the nearby North Arm of Great Slave Lake in late July and early August (but none in June).

In interior Alaska, large post-breeding aggregations of Horned Grebes were found on lakes (about 200-1500 ha, <5 m deep) in both the Tetlin and Yukon Flats regions (Table 1). At the time of banding operations, these lakes were warm (average surface temperature 22°C) and had abundant inverte-

Table 1. Numbers of adult Horned Grebes banded or recaptured in July and August at lakes in Tetlin and Yukon Flats regions of Alaska (J. G. King, unpubl. data; King 1963).

Year	Location	No. of lakes	Number banded	Number recaptured
1956	Tetlin	4	105	0
1957	Tetlin	3	56	0
1958	Tetlin	5	118	0
1959	Tetlin	2	150	5
1960	Tetlin	4	554	40
1960	Yukon Flats	4	556	0
1961	Yukon Flats	7	229	55
1962	Yukon Flats	1 (Ohtig Lake)	About 1,500*	13

*Horned Grebes were released without banding.

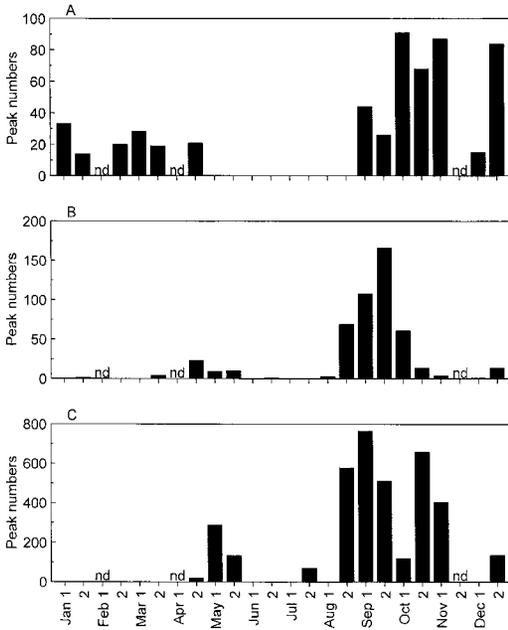


Figure 1. Seasonal abundance of Horned Grebe (A), Red-necked Grebe (B), and Western Grebe (C) in Boundary Bay, British Columbia as indicated by peak numbers counted in the first (e.g., 1 June) and second (e.g., 2 June) half of each month in the most intensively surveyed area of Boundary Bay, 1995 (nd = no data).

brates. Grebes were captured in July and August and were unable to fly (J. G. King, pers. comm.), suggesting that some were growing remiges, although wing condition was not recorded. The largest concentrations of grebes were found at Ohtig Lake (Yukon Flats 66°3'N, 143°4'W), where on 10-15 August 1962 an estimated 1,500 Horned Grebes were captured (King 1963).

The Alaska birds showed fidelity to specific lakes or the area where they were originally banded. At Tetlin, of the 983 Horned Grebes banded in 1956-1960, 69 (7%) were recaptured there in subsequent years (up to five years after banding). At Yukon Flats, of the 855 banded in 1960-1961, 75 (9%) were recaptured there in subsequent years (up to four years after banding). Because banding and recapture efforts were inconsistent and not quantified, the level of site fidelity is unknown.

At Boundary Bay, British Columbia, the first few Horned Grebes arrived in mid-Au-

gust, and peak numbers were reached in October and November (Fig. 1). No Horned Grebe in wing molt was observed in Boundary Bay.

Red-necked Grebe

Adult Red-necked Grebes undergo a complete prebasic molt, including simultaneous molt of the remiges, in late summer and early fall (Cramp and Simmons 1977; Stout and Nuechterlein 1999). In Europe, Red-necked Grebes typically move to shallow saltwater locations for molt (Folkestad 1978; Pihl 1995; Vlug 1996). However, a small but apparently growing number of Red-necked Grebes molt flight feathers on interior freshwater sites in northern Germany (some sites also used by breeding grebes, though not necessarily the same individuals) and in Switzerland (Vlug 2000).

In North America, adult Red-necked Grebes depart breeding lakes from July to mid-September. They arrive at Pacific Coast locations in August and September. Great Lakes and Atlantic-wintering Red-necked Grebes pass through Lake Superior on migration peaking in August and early September. The first grebes arrive on the Atlantic coast in August, with peak arrival in October and November (Stout and Nuechterlein 1999).

At YKSA, 29 known nesting adults under regular observation in 1998 and 1999 left their breeding ponds between mid-July and late August. All retained old flight feathers during their stay on the breeding ponds.

At Chaleur Bay (Quebec and New Brunswick), on 30 September 1974, Canadian Wildlife Service biologists examined 195 oiled Red-necked Grebes, and all were in wing molt (A. Erskine, pers. comm.). Surveys at the Gulf of St. Lawrence from 19 to 23 September 1994 found 136 Red-necked Grebes at Chaleur Bay, 136 at Baie Verte (Nova Scotia/New Brunswick); and 52 at other locations. At each site, individuals in wing molt were detected.

Grebes arrived in Boundary Bay, British Columbia in August and September, but most departed in October (Fig. 1). At three

locations in Boundary Bay, a total of 1,689 Red-necked Grebes was counted on 24 September 1997. In 1998, counts at these three locations were 7 September - 883, 10 September - 1,670 (two of three locations), 22 September 1998 - 2,229, 6 October - 1,325, 10 October - 333. The grebes were undergoing body molt, and some birds were in wing molt or regrowth. For example, on 10 September 1998, ten of 14 birds seen wing-flapping had noticeably incompletely grown remiges. Red-necked Grebes were typically found in shallow portions of the subtidal zone (<13 m deep at low tide) but also used the intertidal zone on high tides.

Freshwater wing-molt locations were found in northern Lake Huron. From 20 August to 6 October 1994, 1,105 Red-necked Grebes were found at 16 locations around the shore of Manitoulin Island, Ontario. On 15 September 1995, 1,248 Red-necked Grebes were counted at six of the Manitoulin sites (the total at these six sites in 1994 was 726). Wing-flapping grebes seen from shore were in wing molt. Red-necked Grebes were found in sheltered areas (large bays or lee sides of islands) with water depths of 3-55 m, usually near shelves and holes (Stout 1995).

Western Grebe

Western Grebes undergo a complete annual molt which peaks in late summer (July to September) (Storer and Nuechterlein 1985). Western Grebes in wing molt have been found on freshwater lakes and at coastal locations. In a mixed sample of 158 Western Grebes and Clark's Grebes (*Aechmophorus clarkii*) taken at Clear Lake and Topaz Lake, California, 21 adult grebes were in some stage of regrowth of remiges. The 21 adults with growing remiges were taken between 24 July and 18 October (Storer and Nuechterlein 1985). In Manitoba, banded breeding birds from Lake Manitoba were caught on Lake Winnipegosis following breeding (Storer and Nuechterlein 1992). Some of these birds were growing new remiges (G. L. Nuechterlein and R. W. Storer, pers. comm.). Western Grebes that disperse by swimming (often with young) from nest

sites on Delta Marsh to open waters of Lake Manitoba may molt their remiges on Lake Manitoba (R. W. Storer, pers. comm.). At coastal sites, five of 20 Western Grebes (ages unknown) collected on 17 October 1985 in Commencement Bay, Washington were in molt (Henny *et al.* 1990). At Santa Barbara Channel, California, about 10% of *Aechmophorus* grebes (ages unknown) salvaged after an oil spill on 28 January 1969 were in some stage of regrowth of remiges (Sibley 1970).

The main autumn movement of northern-breeding Western Grebes occurred from September to early November, with peak passage in October (Riske 1976; Campbell *et al.* 1990; Storer and Nuechterlein 1992). At most coastal locations, migrant Western Grebes arrived in mid-September, and numbers increased from October through December (Campbell *et al.* 1990; Storer and Nuechterlein 1992; Clowater 1998). In contrast, the influx of migrant Western Grebes at Boundary Bay, British Columbia began as early as late July in some years, with peak numbers reached in September and declining through October and November (Fig. 1).

It is difficult to estimate the total number of Western Grebes using Boundary Bay during the molt period due to problems of detecting birds distant from the shore. Western Grebes were concentrated along the margins of deeper portions of Boundary Bay, in a zone near or just beyond the 5-m low-tide depth line, with some birds moving into shallower subtidal and inundated intertidal zones on high tides. There were probably several thousand occupying Boundary Bay each autumn. At one 2-km² area consistently occupied by Western Grebes each August and September, about 3,000 were observed on 7 September 1998. On 22 September 1998, during a tally of a close flock of 333 Western Grebes, the three birds seen wing-flapping were all growing new remiges.

DISCUSSION

The vast majority of Horned, Red-necked and Western Grebes in North America molt at unknown locations. However, our data sug-

gest that following breeding, all three species move to special locations for the period of wing molt and regrowth, before progressing to wintering sites. In general these molt locations are larger bodies of water than those used for nesting, and may be within the breeding range, wintering range or both. Horned Grebes appear to move from breeding ponds to larger inland waters. Red-necked Grebes use coastal sites as well as locations on the Great Lakes, but appear to vacate the area before winter. Boundary Bay, British Columbia, is an example of a coastal site within winter ranges used as a molt location by both Red-necked and Western Grebes but not as a wintering area. An exception to the pattern of using separate areas for breeding and molt occurs in the Western Grebe. On large lakes that remain ice free late into the year or year-round (such as Clear Lake and Topaz Lake, California and the large Manitoba lakes) Western Grebes molt on the same waters they use for breeding.

The pattern of moving to special molt locations we observed in Horned, Red-necked and Western Grebes is similar to that found in the Eared and Great Crested Grebes. The apparent lack of molt migration in migratory Pied-billed Grebes (Muller and Storer 1999) may reflect the similarities between their breeding and non-breeding habitats.

Since grebes typically do not fly while on their breeding territory, they could molt remiges while at the breeding sites, assuming that energetic requirements for the molt and breeding overlap are not prohibitive. However, flight feathers may be needed for adults to effectively "back-brood" their small chicks. Parents back-brood chicks almost continuously for one to three weeks after hatching. Back-brooding adults raise their wings slightly to cover their chicks (Storer and Nuechterlein 1992; Stout and Nuechterlein 1999; Stedman 2000). Secondly, should they remain on breeding territories to molt, especially on small water bodies, adults would potentially have to compete with their own independent, but still flightless, young for food resources through part or all of the wing molt period (see also discussion in Fournier and Hines 1999).

Within the strategies observed in Horned, Red-necked and Western Grebes there are variations in how much of the total autumn migration distance remains to be completed after molt. By using interior molt sites and delaying migration until after molt, grebes increase the risk of encountering hazardous weather conditions during migration (see examples of weather hazards summarized in Cullen *et al.* 1999; Jehl *et al.* 1999; Stout and Nuechterlein 1999; Stedman 2000). On the other hand, postponing movements to a later date offers a longer nocturnal period in which to complete overland movements (overland migration is nocturnal in grebes) (Jehl 1997). Another advantage is that these grebes would complete most of their migratory movement with fresh remiges.

As in the Eared Grebe, Great Crested Grebe and other birds with molt migrations, the potential to take advantage of sites with both a rich food supply and larger surface area (with more room to evade predators than at most breeding sites) is likely important in molt strategies (Salomonsen 1968). Lakes in Alaska used by post-breeding Horned Grebes were rich in invertebrates (King 1963). Boundary Bay, British Columbia, used by molting Red-necked and Western Grebes, is well known for its abundant marine and bird life (Butler and Campbell 1987; Butler 1992; Butler and Vermeer 1994).

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