A Comparison of Counts of Migrating Red-tailed Hawks Seen at Hawk Mountain Sanctuary and Bake Oven Knob, Pennsylvania, 1961-2000.

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Introduction

The Appalachian Mountains of eastern North America provide many sites for viewing raptors as they migrate each autumn to their wintering grounds. At least 48 watchsites along the range have organized annual counts of these migrants (Heintzelman 1986, Zalles and Bildstein 2000). In the central Appalachians of eastern Pennsylvania, annual counts have been made at Hawk Mountain Sanctuary since 1934, and at Bake Oven Knob since 1961 (Bednarz et al. 1990, Kunkle 2002).

The Red-tailed Hawk (*Buteo jamaicensis*) is one of 16 species of diurnal raptors that migrate along the Kittatinny Ridge, and the species is counted at both Hawk Mountain Sanctuary and Bake Oven Knob. Red-tailed Hawks breed from central Alaska east to Hudson Bay and south into Central America. Most northern Red-tailed Hawks (i.e., those that breed north of 50°) move south for from three to five months each winter, while others remain on their breeding grounds. Many mid-latitude Red-tailed Hawks (i.e., those that breed from 45° to 50° N), and most individuals breeding farther south do not leave their breeding grounds in winter. Red-tailed Hawks that migrate south from northern breeding grounds usually winter in the southern United States and northern Mexico (Preston and Beane 1993).

In general, juvenile Red-tailed Hawks begin migrating earlier in the autumn than do adults (Preston and Beane 1993). Autumn migration usually begins in August and ends in December, with peak movements occurring in early November (Preston and Beane 1993). Weather can influence the amount of visible migration and type of flight used by Red-tailed Hawks (Maransky et al. 1997). Although migrating Red-tailed Hawks use both slope soaring and thermal soaring, thermal soaring is more common early in migration, and slope soaring is more common later in autumn (Maransky et al. 1997).

To examine the extent to which Red-tailed Hawks engage in slope soaring along Appalachian ridges during autumn migration, we compared annual counts of migrating Red-tailed Hawks at Hawk Mountain Sanctuary and Bake Oven Knob from 1961 though 2000, and monthly counts at the two sites from 1982 through 2000. The two sites are 26 km apart along the Kittatinny Ridge, the southernmost mountain in the central Appalachians of eastern Pennsylvania, United States. The ridge runs 300-km northeast to southwest from southeastern New York to southcentral Pennsylvania.

Methods

Hawk Mountain Sanctuary (40° 38' N, 75° 59' W) is a mountaintop site on the Kittatinny Ridge. The Sanctuary is in northern Berks and southern Schuylkill counties, 10 km west of Kempton. Migrating raptors have been counted at Hawk Mountain's North Lookout since autumn 1934. Over the years, the annual count effort has become increasingly consistent. Currently the count is conducted from 0800 to 1700 EST on most days (weather permitting), from 15 August through 15 December (Bednarz et al. 1990). Mean annual count effort was 759 ±202 (range = 315-1105) hours between 1961 and 2000, and 934 ±89 (range = 769-1105) hours between 1982 and 2000 (Tables 1 and 2).

Bake Oven Knob (40° 44' N, 75° 44' W) is a mountaintop watchsite along the Kittatinny Ridge, 26 km northeast of Hawk Mountain Sanctuary. The watchsite is in northern Lehigh County, Pennsylvania, 8 km west of Slatington (Kunkle 2002). Counts have been conducted at the site since 1961 (Heintzelman 1975).

Three different rock outcrops have been used to watch hawks at Bake Oven Knob: South Lookout, North Lookout, and North Side. The South Lookout is used when winds have a southerly component, and the North Lookout is used in winds with a northerly component. The North Side is used on rare occasions when winds have a northerly component but the North Lookout cannot be reached (Kunkle 2002). Counts are made from only one lookout at a time.

The official Bake Oven Knob Hawk Count is conducted from 15 August through the Sunday after Thanksgiving (late November) (Kunkle 2002). Counts are made for a minimum of seven hours most days, mainly from 0900 to 1600 EST, except during periods of rain and fog, (Kunkle 2002). Additional hours are spent counting during times of peak migration (i.e., September and October). The mean annual count effort from 1961 to 2000 was 403 ±166 (range = 36-745) hours, and from 1982 to 2000 it was 431 ±147 (range = 117-745) hours (Tables 1 and 2).

At both sites, raptors are identified with binoculars, and sometimes telescopes. Hawks are counted as migrants if they are seen flying from north of the lookout to south of the lookout (Bednarz et al. 1990).

Annual data were available for both sites from 1961 through 2000 (Table 2, Figure 1). Monthly data were published at both sites beginning in 1982. Therefore, we analyze the Red-tailed Hawk monthly counts for 1982 through 2000 separately from annual counts for the years 1961 through 2000. Counts were compared using a Pearson's correlation coefficient, and two-tailed *t*-tests (Hampton 1994).

Table 1. Summary statistics for hours of observation and hourly rates of passage of Red-tailed Hawks at Hawk Mountain Sanctuary and Bake Oven Knob, Pennsylvania, 1961-2000.

	Hours of observation		Red-tailed Hawks hour^{-1}	
Period	Hawk Mountain Sanctuary	Bake Oven Knob	Hawk Mountain Sanctuary	Bake Oven Knob
1961-2000				
All season	759 ± 202 (315-1105) [27%][a]	402 ± 164 (36-744) [41%]	4.8 ± 1.3 (2.3-8.3) [28%]	4.9 ± 1.5 (2.7-9.0) [31%]
1982-2000				
All season	934 ± 89 (769-1105) [10%]	431 ± 143 (117-744.5) [33%]	4.0 ± 0.9 (2.3-6.0) [22%]	4.5 ± 1.4 (2.7-7.9) [31%]
September	268 ± 24 (222-319) [9%]	152 ± 41 (51-234) [27%]	0.7 ± 0.3 (0.3-1.5) [42%]	0.4 ± 0.2 (0.0-0.7) [43%]
October	275 ± 18 (247-302) [7%]	155 ± 47 (24-242) [30%]	5.4 ± 2.1 (1.2-8.8) [39%]	5.1 ± 2.0 (1.9-9.8) [40%]
November	213 ± 26 (148-252) [12%]	83 ± 42 (27-170) [51%]	9.5 ± 4.0 (4.0-17.2) [42%]	12.5 ± 5.6 (6.0-24.6) [46%]

[a] Mean ± Standard Deviation (Range) [Coefficient of Variation %]

Table 2. Hours of observation, numbers of Red-tailed Hawks seen, and hourly rates of passage of Red-tailed Hawks at Hawk Mountain Sanctuary and Bake Oven Knob, Pennsylvania, 1961-2000.

	Hawk Mountain Sanctuary[1]			Bake Oven Knob[2]		
Year	Hours of Observation	Number of Red-tailed Hawks	Red-tailed Hawks Hour^{-1}	Hours of Observation	Number of Red-tailed Hawks	Red-tailed Hawks Hour^{-1}
1961	665	2563	3.85	36	129	3.58
1962	636	2771	4.36	116	733	6.32
1963	710	3401	4.79	155	881	5.68
1964	686	2626	3.83	258	938	3.64
1965	683	3297	4.83	353	1276	3.61
1966	575	2126	3.70	363	1165	3.21
1967	546	1844	3.38	362	1020	2.82
1968	511	3765	7.37	349	2149	6.16
1969	754	3364	4.46	488	2831	5.80
1970	445	2502	5.62	604	3191	5.28
1971	315	1781	5.66	591	3572	6.04
1972	418	3463	8.29	654	3250	4.97
1973	508	3098	6.10	652	2792	4.28
1974	531	3658	6.90	539	3137	5.82
1975	490	2880	5.88	472	2802	5.94
1976	557	3694	6.63	531	2336	4.40
1977	536	3503	6.54	381	2920	7.66
1978	656	2852	4.35	378	1798	4.76
1979	732	4175	5.70	197	780	3.96
1980	857	5711	6.66	175	1574	8.99
1981	794	3939	4.96	260	1693	6.51
1982	826	5001	6.06	546	3732	6.84
1983	850	3943	4.64	441	1997	4.53
1984	905	3152	3.48	511	1901	3.72
1985	769	2895	3.76	461	1818	3.94
1986	778	3287	4.22	401	1812	4.52
1987	869	4211	4.85	412	2750	6.68
1988	925	4680	5.06	410	2013	4.92
1989	885	3707	4.19	469	2207	4.71
1990	928	3783	4.08	293	911	3.11
1991	946	2949	3.12	117	330	2.82
1992	924	3275	3.54	435	1561	3.59
1993	959	3737	3.90	405	1699	4.20
1994	1030	4395	4.27	303	1389	4.59
1995	965	4789	4.96	279	2188	7.86
1996	994	2720	2.74	355	1524	4.30
1997	1015	2360	2.33	357	1076	3.01
1998	1105	4297	3.89	521	2389	4.59
1999	1022	4953	4.85	730	3843	5.27
2000	1058	2936	2.78	745	1977	2.66

1- HMS unpublished data

2- Heintzelman 1963,1968,1970,1982a,1983, 1984, 1985, 1987, 1988, 1989, 1993, 1994, 1995, 1996, 1997; Heintzelman and MacClay 1972, 1973, 1975, 1976, 1979; Heintzelman and Reed 1982; Heintzelman et al. 1992; WIC data base

Results

The mean hourly rate of passage of Red-tailed Hawks at Hawk Mountain Sanctuary was 4.8 birds hour^{-1} from 1961 through 2000, and 4.0 birds hour^{-1} from 1982 through 2000. From 1982 through 2000 rates of passage were 0.7 in September, 5.4 in October, and 9.5 in November (Tables 1 and 2).

The mean hourly rate of passage of Red-tailed Hawks at Bake Oven Knob was 4.9 birds hour^{-1} from 1961 through 2000, and 4.5 birds hour^{-1} from 1982 through 2000 (Table 2). From 1982 through 2000 rates of passage were 0.4 in September, 5.1 in October, and 12.5 in November (Tables 1 and 2).

Annual rates of passage between the two sites were correlated during both time periods (i.e., 1961-2000 and 1982-2000) (Figure 2). Monthly rates of passage also were correlated during all three months (ie., September, October, and November) (Figure 3), however, the correlations were considerably stronger in October and November than in September.

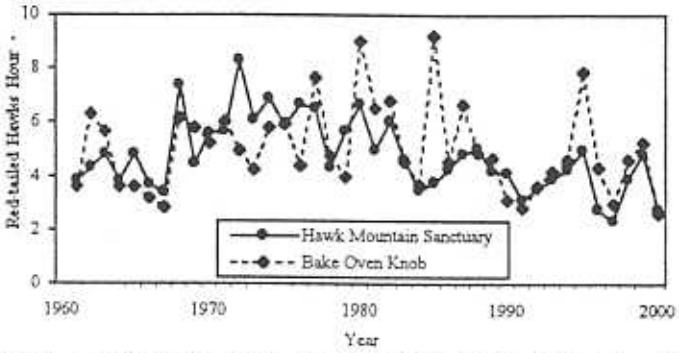

Figure 1. Hourly rates of passage of Red-tailed Hawks at Hawk Mountain Sanctuary and Bake Oven Knob, Pennsylvania, 1961-2000.

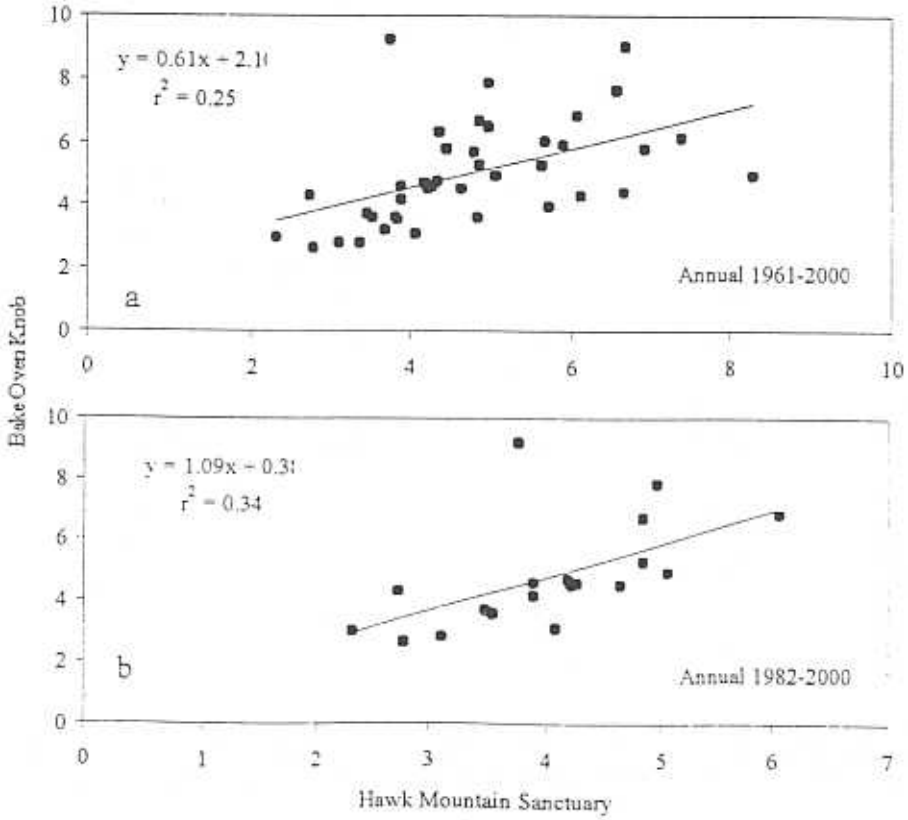

Figure 2. Relationships of annual passage rates of Red-tailed Hawks seen at Hawk Mountain Sanctuary and Bake Oven Knob, Pennsylvania, (a) 1961-2000, (b) 1982-2000.

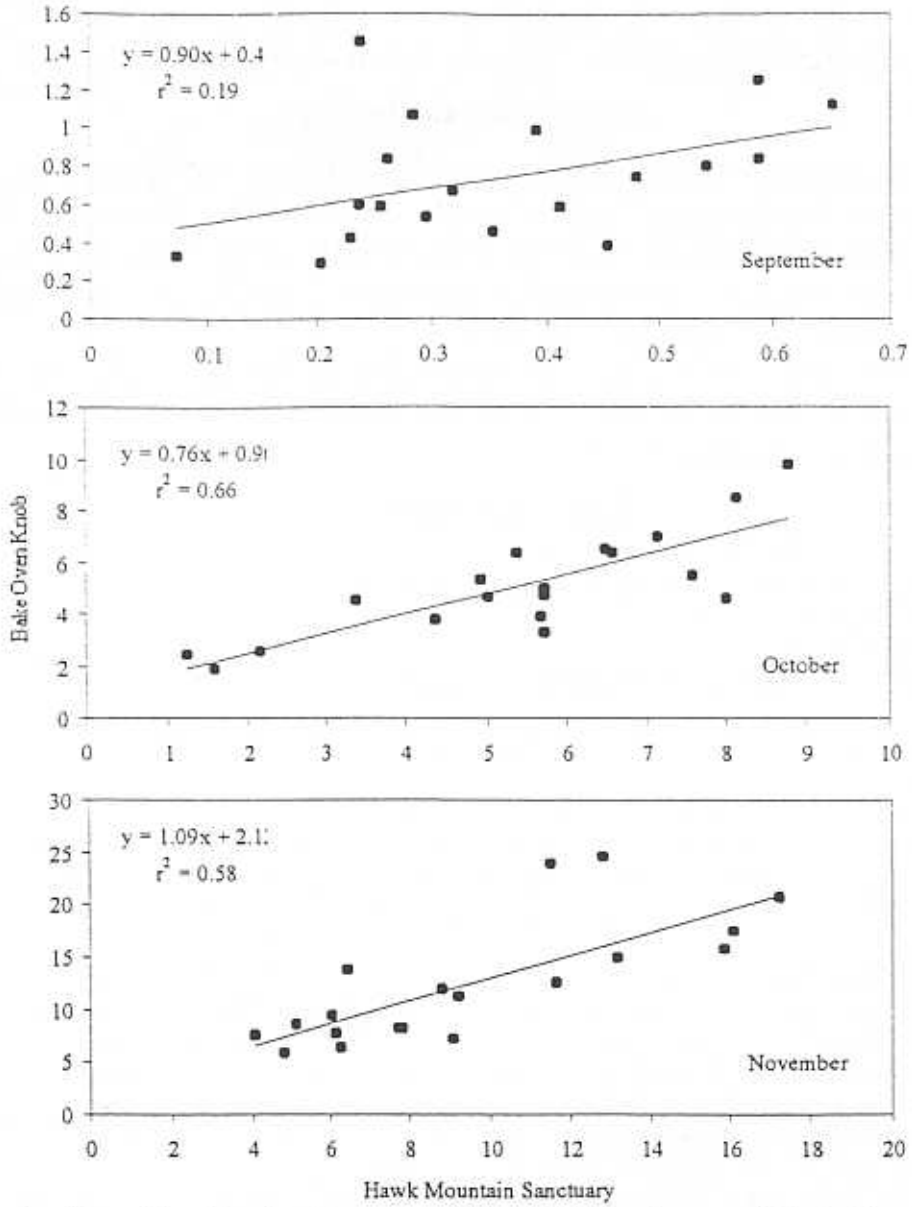

Figure 3. Relationships of hourly rates of passage of Red-tailed Hawks seen at Hawk Mountain Sanctuary and Bake Oven Knob, Pennsylvania (a) September, (b) October, (c) November, 1982-2000. Note the considerably stronger correlations in October and November.

Discussion

The correlation between the annual counts in both 1961-2000 and 1982-2000 suggests that many of the Red-tailed Hawks seen migrating at Bake Oven Knob remain on the Kittatinny Ridge and are also counted at Hawk Mountain, 26 km down ridge. Differences in the strengths of the monthly correlations at the two sites may result from a change in migratory tactics of Red-tailed Hawks. Red-tailed Hawks appear to change their migratory behavior as autumn progresses (Maransky et al. 1997). In September, when strong thermals occur in the region, many Red-tailed Hawks appear to leave the ridge and soar in these pockets of warm rising air, and thus are not seen as often at mountaintop watchsites. Later in autumn, when thermals are weaker and less frequent, Red-tailed Hawks appear more likely to use mountain updrafts and slope soaring (Maransky et al. 1997). We believe that this seasonal shift in migration behavior is responsible for the stronger inter-site correlations in counts in October and November than in September.

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Literature cited

Bednarz, J.C., D. Klem, Jr., L.J. Goodrich, and S.E. Senner
1990 Migration Counts of Raptors at Hawk Mountain, Pennsylvania, as Indicators of Population Trends, 1934-1986. *Auk*, 107:96-109.

Dunne, P., D. Sibley, and C. Sutton
1988 *Hawks in Flight*. Houghton Mifflin Company, Boston, MA.

Hampton, R.E.
1994 *Introductory Biological Statistics*. McGraw-Hill, Boston, MA.

Heintzelman, Donald S.
1963 Bake Oven Hawk Flights. *Atlantic Naturalist* 18(3): 154-158.
1968 Bake Oven Knob Autumn Hawk Migration Observations, 1966 and 1967. *Cassinia*, 50: 26-27.
1970 Bake Oven Knob Autumn Hawk Migration Observations, 1957 and 1969. *Cassinia*, 52: 37.
1975 *Autumn Hawk Flights: The Migrations in Eastern North America*. Rutgers University Press, New Brunswick, NJ.
1979 *A Guide to Hawk Watching in North America*. Penn State University Press, University Park, PA.
1982a Hours of Observation at the Bake Oven Knob, Pennsylvania Hawk Lookout. *Cassinia*, 59: 78.
1982b The 1982 Autumn Hawk Count at Bake Oven Knob, Pennsylvania. *American Hawkwatcher*, 5: 1-6.
1983 The 1983 Autumn Hawk Count at Bake Oven Knob, Pennsylvania. *American Hawkwatcher*, 8: 1-6.
1984 The 1984 Autumn Hawk Count at Bake Oven Knob, Pennsylvania. *American Hawkwatcher*, 9: 1-5.
1985 The 1985 Autumn Hawk Count at Bake Oven Knob, Pennsylvania. *American Hawkwatcher*, 10: 1-4.
1986 *The Migrations of Hawks*. Indiana University Press, Bloomington, IN.
1987 The 1986 Autumn Hawk Count at Bake Oven Knob, Pennsylvania. *American Hawkwatcher*, 11: 1-2.
1988 The 1987 Autumn Hawk Count at Bake Oven Knob, Pennsylvania. *American Hawkwatcher*, 12: 1-2.
1989 The 1988 Autumn Hawk Count at Bake Oven Knob, Pennsylvania. *American Hawkwatcher*, 13: 1-2.
1990 The 1957-1989 Bake Oven Knob, Pa., Autumn Hawk Migration Field Study: A 30 Year Review and Summary. *American Hawkwatcher* , 17: 1-16.
1993 The 1992 Autumn Hawk Count at Bake Oven Knob, Lehigh County, Pa. *American Hawkwatcher*, 19: 2-3.
1994 The 1993 Autumn Hawk Count at Bake Oven Knob, Lehigh County, Pa. *American Hawkwatcher*, 20: 2-3.
1995 The 1994 and 1995 Autumn Hawk Counts at Bake Oven Knob, Lehigh County, Pa. *American Hawkwatcher*, 21: 2-4.
1996 The 1996 Autumn Hawk Count at Bake Oven Knob, Lehigh County, Pa. *American Hawkwatcher*, 22: 2-4.
1997 The 1997 Autumn Hawk Count at Bake Oven Knob, Lehigh County, Pa. *American Hawkwatcher*, 23: 2-4.

Heintzelman, Donald S., and Robert MacClay
1972 The 1970 and 1971 Autumn Hawk Counts at Bake Oven Knob, Pennsylvania. *Cassinia*, 53: 3-23.
1973 The 1972 Autumn Hawk Count at Bake Oven Knob, Pennsylvania. *Cassinia*, 54: 3-9.
1975 The 1973 and 1974 Autumn Hawk Counts at Bake Oven Knob, Pennsylvania. *Cassinia*, 55: 17-28.
1976 The 1975 Autumn Hawk Count at Bake Oven Knob, Pennsylvania. *Cassinia*, 56: 15-21.
1979 The 1976, 1977, and 1978 Autumn Hawk Counts at Bake Oven Knob, Pennsylvania. *Cassinia*, 57: 19-20.

Heintzelman, Donald S. and Barry Reed
1982 The 1979, 1980, and 1981 Autumn Hawk Counts at Bake Oven Knob, Pennsylvania. *Cassinia*, 59: 62-64.

Heintzelman, Donald S., Dan Kunkle, John Leskosky, and Barry Reed
1992 The 1990 and 1991 Autumn Hawk Counts at Bake Oven Knob, Lehigh County, Pennsylvania. *American Hawkwatcher*, 18: 5-7.

Kunkle, D.R.
2002 *Bake Oven Knob's Hawk Counter's Manual.* In Press. Wildlife Information Center, Slatington,PA.
Maransky, B., L. Goodrich, and K. Bildstein
1997 Seasonal Shifts in the Effects of Weather on the Visible Migration of Red-tailed Hawks at Hawk Mountain, Pennsylvania, 1992-1994. *Wilson Bulletin*, 109:246-252.
Preston, C.R. and R.D. Beane
1993 Red-tailed Hawk (Buteo jamaicensis). In *The Birds of North America*, No. 52 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA; The American Ornithologists Union, Washington,D.C.
Zalles, J.I. and K.L. Bildstein
2000 *Raptor Watch: A Global Directory of Raptor Migration Sites* (Bird Life Conservation Series No. 9): Bird Life International, Cambridge, UK; Hawk Mountain Sanctuary, Kempton, PA.

Short Field Notes

Broad-winged Hawk "Playing" with a Leaf

It was 25 August 2001, the first day on Bake Oven Knob for most of us this season. Dan Kunkle was giving an orientation talk to the volunteers, when somebody called out "Bird over the woods." An immature Broad-winged Hawk had come in low over the trees on the north side of south lookout. Just then, it dove into the trees and came out with something in its talons. One of the volunteers shouted, "It got a bird!" I noticed what it was holding was orange and yelled "No, it's a monarch!" thinking the hawk had caught a butterfly. It flew across the front of the lookout and dropped what it was holding for all of us to see. It was just a couple of leaves. You could almost hear the disappointment (or maybe relief?) that we hadn't seen a kill. Suddenly, the hawk looped back around and in flight caught one of the floating leaves in its talons. That got a reaction from the crowd! It flew about ten feet down-ridge and dropped the leaf again. Once more, it looped back and again plucked the leaf out of mid-air. Finally, the hawk dropped the leaf one last time and flew on down the ridge.

We were all amazed by what we'd seen. While all of us at one time had seen hawks catch their prey on the wing, and a couple of us remarked that we'd seen swallows play with leaves and feathers like that, none of us had ever seen a hawk "play" with a leaf in such a manner, nor do we understand the purpose or meaning of the activity. I searched Bent's life history but there is no mention of such behavior.

Literature Cited

Bent, A. C.
1938 *Life Histories of North American Birds of Prey, Part Two.* Smithsonian Bulletin 170. U. S. Government Printing Office, Washington D. C.

Jeffrey Hopkins, 1225-6 Pericles Place, Whitehall, PA 18052

Red-tails, Raven, and Turkey Vulture Interaction

At 10:52 EST on 29 August 2001, Dan Kunkle and I were on the North Lookout when we observed a Red-tailed Hawk hunting over the feature known as "the Hump." It was joined by a Common Raven and the two began "dueling" as described in Kunkle's (2000) note in last year's *American Hawkwatcher*. Soon, a second Red-tail joined in the aerial display. On several occasions, one of the hawks made a pass at the raven, which the raven deftly avoided. Whether these passes were aggressive or playful could not be determined. The raven also flew toward the Red-tails, almost as though to instigate a chase. The threesome was then joined by a Turkey Vulture who soared around with the others. Both Red-tails and the raven all made passes at the vulture which also reacted quickly to avoid the "attacker." In addition, the Red-tails made passes at each other. All of this activity lasted less than five minutes. While no clear motives could be established for any of this behavior, it certainly gave the appearance of play. The involvement of the Turkey Vulture was surprising as we have never observed them to engage in this kind of behavior with other vultures. The vulture clearly initiated its part of the interaction, as it moved toward the others and deliberately soared around with them.