The Birds of North America, No. 218, 1996

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Buteo platypterus

FRENCH:
Petite Buse

SPANISH:
Busardo aliancho

Broad-winged Hawk

The Broad-winged Hawk is a small, stocky buteo with conspicuous, broad white-and-black tail bands. A common breeder in large, deciduous or mixed-deciduous forests throughout northeastern and northcentral North America, this species is secretive while nesting but conspicuous in migration. It is one of the few North American raptors that flocks during migration; tens of thousands of Broad-winged Hawks are commonly seen at the peak of their fall and spring migrations in southern Texas, Mexico, and Central America.

Nesting pairs spend most of their time beneath the forest canopy, perch-hunting for insects, amphibians, reptiles, mammals, and birds. Territorial adults can be located by their plaintive *peee-uurr* whistle, given during occasional soaring flights above the canopy. Wintering birds inhabit forest and forest edges from southern Mexico south through Brazil and Bolivia. Small numbers of mostly immature birds winter in south Florida and the Florida Keys. Endemic subspecies occur on several Caribbean islands.

The Birds of North America

Life Histories for the 21st Century

Although some aspects of the Broad-winged Hawk's migration behavior and breeding ecology have been well-documented, little is known about the species' wintering ecology and other facets of its life history. Many observations of its life history come from one early study (Burns 1911), and much remains poorly documented.

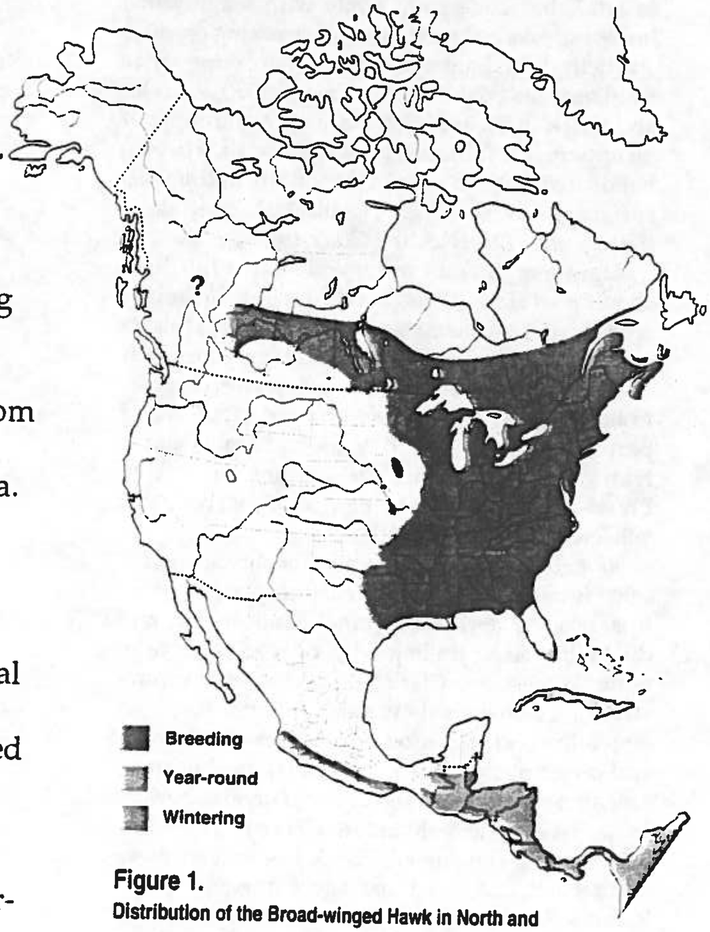

Figure 1.
Distribution of the Broad-winged Hawk in North and Middle America and the Caribbean. The breeding range also includes many islands in the eastern Caribbean (see text for details).

Few studies have examined color-marked birds or have followed individuals for more than two years.

DISTINGUISHING CHARACTERISTICS

Second smallest North America buteo; total length 34–44 cm, mass 265–560 g, wingspan 81–100 cm (Friedmann 1950, Mosher and Matray 1974). Sexes similar in plumage, but females slightly larger (e.g., 3–6% longer wings) and heavier (e.g., 22% heavier in spring) than males (Mosher and Matray 1974, Appendix 3).

Two color morphs exist. Adult light morph has brown back, cinnamon or chestnut barring below, and whitish throat. Tail black with 1 prominent (20 mm) whitish band across the middle; a less visible, narrower white band near base of tail; and a narrow white band along the edge (Burns 1911, Friedmann 1950). Wing with prominent blackish band along trailing edge.

Juvenile (Juvenal plumage) light morph similar to adult but underparts white with longitudinal brown streaks on breast, heavier streaking on sides and belly (overall amount of ventral streaking varies from very little to heavy; Friedmann 1950, Wheeler and Clark 1995), and with more white throughout on upperparts. Tail is buffy with narrow dark brown bands (band at end of tail is broadest), and undersurface of wing has dusky (not blackish) band along trailing edge (Wheeler and Clark 1995).

Light-morph adult most similar to adult Red-shouldered Hawk (*Buteo lineatus*), but Red-shouldered Hawk has rufous shoulders, longer legs, black-and-white bars on remiges, and more white bands on tail; in flight, Red-shouldered Hawk also appears to holds its wings stretched forward (not flat and perpendicular to the body as in Broad-winged Hawk), and its wingtips are less pointed than in Broad-winged Hawk (Dunne et al. 1988, Brett 1991, Wheeler and Clark 1995).

Juvenile light morph generally distinguished from other immature buteos by small size, pointed wingtips, broader dark subterminal band on tail, and dusky bar along trailing edge of undersurface of wing (Wheeler and Clark 1995). Amount of ventral streaking below highly variable. Ventral streaking generally concentrated on sides of breast with throat and center of breast with little streaking, but some juveniles show more or less uniform streaking below as in juvenile Red-shouldered Hawk. However, juvenile Red-shouldered Hawk has longer, more slender tail, and all tail bands are of equal width. Juvenile Red-tailed Hawk (*Buteo jamaicensis*) is much larger with ventral streaking concentrated across abdomen (i.e., belly band), a clear breast (Preston and Beane 1993), and tail bands of equal width. Juvenile light-morph Short-tailed Hawk (*B. brachyurus*) has less streaking below, prominent dark cheek patches, and wingtips reaching end of tail when perched (Wheeler and Clark 1995).

Adult dark morph (melanistic) is entirely dark sooty brown with tail similar to light morph, but undersurface of remiges silvery contrasting with dark brown underwing-coverts. Back notably darker than wings. Dark morph rare, found mainly in northwestern and northcentral portions of range (Burns 1911, Bailey 1917, Brown and Amadon 1968); <0.1% of migrants observed in e. Mexico are melanistic (J. Montejo, E. Ruelas Inzunza pers. comm.). Adult dark-morph Short-tailed Hawk similar, but undersurface of tail largely whitish with single dark subterminal band (Wetmore 1965, Wheeler and Clark 1995).

Juvenile dark morph similar to adult, but more rufous on breast and more tawny streaking on body (Friedmann 1950, Wetmore 1965, Wheeler and Clark 1995).

Some West Indian subspecies appear smaller than mainland birds (Appendix 3). *Buteo platypterus antillarum* is notably smaller and more rufuscent or tawny with heavy streaking on throat. Has rufous edging on dorsal feathers, particularly on hindneck and upper back (Friedmann 1950, Blake 1977). West Indian juveniles appear more heavily streaked or tawny on underside, versus whiter plumage of North American *B. p. platypterus* (Friedmann 1950). For additional information on distinguishing Broad-winged Hawk, see Dunne et al. 1988.

DISTRIBUTION

THE AMERICAS

Breeding range. Figure 1. In North America, deciduous or mixed deciduous-coniferous forests from central Alberta (Semenchuk 1992), central Saskatchewan, central Manitoba (Godfrey 1986), n.-central Ontario (Cadman et al. 1987), s.-central Quebec (Cyr and Larivee 1995), New Brunswick, Prince Edward I. (possibly), and Nova Scotia, including Cape Breton I. (Erskine 1992), south to se. Alberta (Semenchuk 1992), s.-central Saskatchewan, ne. North Dakota (Stewart 1975), n. and se. Minnesota (Janssen 1987), e. Iowa (L. Jackson pers. comm.), Missouri (except in northwest; Robbins and Easterla 1992), se. Oklahoma (Baumgartner and Baumgartner 1992), e. Texas (K. Arnold pers. comm.), and along Gulf Coast to n. Florida (south to Levy and Aluchua counties; Robertson and Woolfenden 1992). Also breeds in ne. Kansas (Thompson and Ely 1989), central and sw. Iowa (L. Jackson pers. comm.), and very locally elsewhere along e. Great Plains where appropriate habitat exists. Rare summer visitor and

MIGRATION

NATURE OF MIGRATION IN THE SPECIES

One of 5 North American diurnal birds of prey that are complete migrants (Kerlinger 1989). Continental populations vacate their breeding range during winter; endemic Caribbean subspecies are resident.

Generally migrates in large flocks, or "kettles," ranging from several individuals to thousands (Fig. 2). Migrants frequently soar in thermals. Kettles of tens of thousands of birds are regularly sighted in s. Texas, Mexico, and Central America, occasionally along shores of Great Lakes, more rarely elsewhere. Lone migrants are rare; only 12% of fall migrants sighted in central New York flew alone (Kerlinger 1989).

Although the overall migration period at any given location in spring and fall may last 2 mo, most individuals pass during a brief and concentrated 2 wk period during both seasons (Bednarz et al. 1990, Ruelas Inzunza et al. 1993).

In Mexico and Central America, associates with flocks of Swainson's Hawks, Turkey Vultures (*Cathartes aura*), and Mississippi Kites (*Ictinia mississippiensis*) as well as with solitary raptor migrants such as Osprey (*Pandion haliaetus*) or Cooper's Hawk (*Accipiter cooperii*) (Skutch 1945, Wetmore 1965, Andrele 1966, Ruelas Inzunza et al. 1993).

ROUTES OF MIGRATION

North America. Kerlinger et al. (1985) suggest that this species uses an elliptical migration path to compensate for prevailing winds in spring and fall (see Migration Behavior, below); hypothesized route from and to e. Canada is more easterly in fall and more westerly in spring.

Broad-front migrant throughout its breeding range in e. U.S. and Canada, as well in eastern plains states and e. New Mexico; rare but regular through w. U.S., along California coast, and north to British Columbia (Am. Ornithol. Union 1983, McDermott 1994). Numbers concentrate, however, where topography funnels migrants, or where human-made features, such as cities, increase thermal strength. Migration routes skirt large bodies of water, although short water crossings occur regularly, especially where peninsulas or islands shorten the distance (e.g., over Bay of Fundy between Nova Scotia and Maine or New Brunswick); occasional wider crossings reported (e.g., Florida Keys to Cuba; MacRae 1985).

Fall. Individuals from e. and central Canada head south skirting Great Lakes and Atlantic shoreline; thousands pass northern and western shores of Great Lakes (e.g., 228,176 on western shore of Lake Erie on 19 Sep 1994; Cypher and Smart 1995), e. Appalachian Mtns., and Connecticut and New York coasts. Eastern migration route moves inland through n. New Jersey and se. Pennsylvania; flight lines disperse along southern Appalachian ridges, with smaller flocks observed from Maryland to Tennessee. Most migrants presumably head southwesterly, through Louisiana and e. Texas, to fly around the Gulf of Mexico. Central Flyway birds appear to disperse south through Mississippi Valley to converge with Eastern Flyway birds in Texas.

Figure 2. Broad-winged Hawks often form large flocks or "kettles" during fall migration. Drawing by John Schmitt.

Migration routes west of Mississippi River poorly known. Small, but increasing, numbers follow Rocky Mtns. south, with annual counts averaging 25–30 birds in Goshutes Mtns., NV (S. Hoffman pers. comm.). Small numbers, 50–150/yr, occur along California coast and in Baja California (McDermott 1994).

Migrants flying south along ridges in Pennsylvania are predominantly adult (63–85% from 1987 to 1994; LJG); those sighted along Atlantic Coast are mostly juveniles (C. Sutton *in* Darrow 1983).

Spring. Except for Great Lakes region, where birds concentrate along southern shorelines, and s. Texas, where thousands may pass each day, spring migration is more dispersed than fall, with few notable concentrations reported.

South of U.S. Migration south of U.S. not as well documented. Most Broad-winged Hawks leave and enter U.S. through se. Texas. In Mexico, migrants follow Gulf of Mexico slope and adjacent foothills, and also Pacific slope south of the Isthmus of Tehuantepec, during spring and fall (Andrele 1966, Ruelas Inzunza et al. 1993, Howell and Webb 1995, possible breeder to Peace Lowlands of ne. British Columbia (Campbell et al. 1990). Occasional sightings north to n. British Columbia, Saskatchewan, and Alberta (Am. Ornithol. Union 1983, Godfrey 1986). Occurs mainly east of Mississippi River; absent from Rocky Mtns. and Newfoundland (Salt and Salt 1976). Casual or transient in western states (Friedmann 1950, DeSante and Pyle 1986).

Endemic subspecies are resident in Cuba (Garrido and Kirkconnell 1993), Puerto Rico (Wiley 1985, Raffaele 1989), Antigua, Dominica, Martinique, St. Lucia, St. Vincent, Grenada, and Tobago; recorded occasionally on Barbados, Hispaniola, and Trinidad (Am. Ornithol. Union 1983, Evans 1990, ffrench 1991). Nesting not confirmed for all of these locations. Reports from other islands in Caribbean may be vagrants from mainland (Brown and Amadon 1968, Am. Ornithol. Union 1983).

Winter range. Figure 1. Winter resident in Mexico along Pacific slope from Colima to Oaxaca, along both slopes from Chiapas, Guatemala, and s. Belize south through Middle America (Ridgely and Gwynne 1989, Howell and Webb 1995), and in South America south to n. and e. Peru, Bolivia, Colombia, Venezuela, and s. Brazil (Am. Ornithol. Union 1983). Widespread in Venezuela north of Orinoco River and along upper Rios Ventuari and Caura in Amazonas (Meyer de Schauensee and Phelps 1978).

Also winters regularly in s. Florida, primarily from Miami south through the Florida Keys (Robertson and Woolfenden 1992), and probably in Cuba (Garrido and Kirkconnell 1993), possibly on other islands, e.g., Puerto Rico and West Indies (Am. Ornithol. Union 1983). Highest early winter abundance north of Mexico is reported west of the Key Colony Beach in Florida Keys (0.37 birds/party-hour on Christmas Bird Counts; Root 1988). Most Florida winterers are juveniles. Juveniles may occasionally winter on lower Mississippi Delta and in coastal Texas as well. Occasionally reported in e. North America north to New England through early winter, but these are probably sick birds or late migrants rather than true winter residents (Friedmann 1950, Tabb 1979; see Migration: routes of migration, below). Also casual in winter along California coast (Small 1994). An increase in number of winter records in s. U.S. since 1950s is reported but unconfirmed.

OUTSIDE THE AMERICAS

Not recorded.

HISTORICAL CHANGES

May be expanding westward; 1980s records in New Mexico, Arizona, Colorado, Wyoming, Idaho, and Montana (DeSante and Pyle 1986, Palmer 1988). Reports of increases in migrants from intermountain West suggest possible range expansion in British Columbia (S. W. Hoffman pers. comm.).

FOSSIL HISTORY

Few data. Scattered fossil records from late Pleistocene (<400,000 yr before present). Reported from several prehistoric sites, including Florida, Iowa, Illinois, Virginia, Puerto Rico (Brodkorb 1964, Ligon 1965). A fossil buteo from late Miocene-early Pliocene resembling a female *Buteo platypterus* was discovered in the Big Sandy Formation of Mohave Co., AZ (Bickart 1990).

SYSTEMATICS

Alexander Wilson first described this species in 1812 and named it *Falco pennsylvanicus*, Penn's Woods Falcon. Viellot's 1823 nomination of *Sparverius platypterus* was the first official binomial designation for this species (Burns 1911, Burtt and Peterson 1995). The dark morph was first described by R. Ridgway in 1886 (Bailey 1917).

GEOGRAPHIC VARIATION; SUBSPECIES

Six subspecies described: *B. p. platypterus* (North American mainland), *B. p. cubanensis* (Cuba), *B. p. brunnescens* (Puerto Rico), *B. p. insulicola* (Antigua, Barbados), *B. p. rivieri* (St. Lucia, Dominica, Barbados, Martinique), and *B. p. antillarum* (Trinidad, Tobago, Grenada, St.Vincent, Grenadines). All but the nominate form are West Indian endemics. *B. p. cubanensis* adult and juvenile have plumage similar to that of juvenile *B. p. platypterus* but are smaller. *B. p. brunnescens* is reportedly the darkest island form and also small. *B. p. insulicola* is the smallest and palest form. *B. p. rivieri* is a small form, but darker than *B. p. insulicola* with a streaked throat. *B. p. antillarum* is smaller than *B. p. platypterus* and has chin and throat more heavily streaked, and is larger than *B. p. rivieri*. All island forms are poorly studied (Friedman 1950, Palmer 1988).

Nominate *B. p. platypterus* has dark and light morphs (see Distinguishing Characteristics, above). Rare dark morph breeds in far western portion of the range and is seen in migration in e. Great Plains and occasionally in w. North America.

RELATED SPECIES

May be closely related to Red-shouldered Hawk and Ridgway's Hawk (*Buteo ridgwayi*; Johnson and Peeters 1963). Chromosome analyses (Schmutz et al. 1993) suggest that the Broad-winged Hawk is the most divergent member of the buteonine subfamily thus far tested, and more closely related to Swainson's Hawk (*B. swainsoni*) and Common Buzzard (*B. buteo*) than to other buteos (Schmutz et al. 1993).

females banded as juveniles in s. Florida were recovered in following years as adults in Mexico and Guatemala (Tabb 1979, SES), suggesting that Florida juveniles migrate to Central America in subsequent years.

Males may winter farther south than females, as a slightly greater proportion of male specimens was recovered in South America, although the difference is not significant if Florida birds are excluded (SES).

MIGRATORY BEHAVIOR

Adept at soaring in thermals; rarely resorts to flapping flight (Kerlinger 1989). Typically soars up in a thermal, then glides to next thermal. Propensity for thermal flight reduces concentration of this species along topographic leading lines such as ridges and coastlines.

Diurnal migrant (Skutch 1945); peak numbers during midday hours at most sites (Kerlinger 1989, LJG).

Appears to migrate at 30–40 km/h, up to 400 km/d through Central America (Smith 1985b). Estimated to spend 40 d migrating, on average, with daily distances varying from 100 km in 6 h of unfavorable conditions to 500 km in 6 h of ridge flight with favorable wind (Kerlinger 1989).

Maximum altitude of most migrants estimated at <800 m; few birds appear to fly above 1,300 m; 12.5% of fall migrants fly above 800 m after 1100 h, with some ascending above 1,200 m (Kerlinger 1985). In New England, altitude of 35 flocks or individuals on fall migration: 650 ± 272 (SD) m (P. Kerlinger pers. comm). In spring migration through New York, >90% fly above 300 m, 31.2% above 800 m (Kerlinger 1985). Cloud cover lowers flight altitude (Kerlinger 1989).

Appears to avoid migrating during strong winds, especially headwinds, and during precipitation (Mueller and Berger 1961, Smith 1980, 1985b); rarely flies in clouds or fog (Kerlinger 1989, LJG). At Hawk Mtn., PA, most migrants are sighted second or third day following a cold front, when winds ebb and thermals increase (Allen et al. 1996).

Compensates for wind displacement during migration. Principal axis of fall migration (PAM) for ne. U.S. = 240°. Fall migrants in central New York fly 156° ± 24 (SD); some wind drift may occur (Kerlinger 1989). Flight direction correlates to wind direction; direction of interthermal glides compensates for displacement by prevailing winds (Kerlinger 1989).

Apparently forages on southbound migration in northern part of range; 8% of 623 migrants sighted at Hawk Mtn., PA, had distended crops (Shelley and Benz 1985); individuals are often seen hawking insects (Heintzelman 1975, LJG). Fall migration coincides with Odonata (dragonfly and damselfly) migration, which may enhance opportunistic feeding. Probably feeds less commonly during passage through Mexico and Central America, but few data.

In s. Texas, migrants leave night roosts 93–271 min after sunrise (Kerlinger and Gauthreaux 1985). Flocks landing in s. Texas maintain integrity until descent, 195–16 min before sunset. After entering a roost, birds appear to remain solitary (Kerlinger and Gauthreaux 1985). Where forest is limited (e.g., in Mexico), many birds may roost in the same tree (see Habitat: spring and fall migration, below).

CONTROL AND PHYSIOLOGY

Fall migration in ne. U.S. associated with good visibility, moderate favorable winds, high temperatures, and afternoons (vs. mornings); this may contrast with Great Lakes where low winds and mornings may be favored (Mueller and Berger 1961, Haugh 1972, Titus and Mosher 1982).

Fall flights at Hawk Mtn., PA, and Hawk Cliff, Ontario, have been correlated with low-pressure systems passing through New England or s. Canada, and northerly winds (Haugh 1972), although such factors may only concentrate migrants rather than induce migration. Spring flights are associated with approaching low-pressure systems and southerly winds (Haugh 1972).

HABITAT

BREEDING RANGE

Nests predominantly in the humid temperate ecoregion domain (Bailey 1989). Breeding range encompasses forest divisions such as oceanic forest-creeping trees; moderate continental mixed forests; forest-alpine meadows; moderately humid broadleaf forest; and oceanic, mixed, constantly humid forest provinces (Bailey 1989). Forests at these midlatitudes consist of broad-leaf and coniferous trees.

Nests in continuous deciduous or mixed-deciduous forests, with openings and water nearby. Forages near small openings in the canopy (Keran 1978, Titus and Mosher 1981, Armstrong and Euler 1983, Crocoll 1984). In New York, nests on slopes more than on level sites (Crocoll 1984). In Minnesota and Wisconsin, uses managed forests, oak (*Quercus*)-aspen (*Populus*) stands 35–50 yr old; nest stands dominated by northern red oak (*Quercus rubra*) with 204 trees/ha, on average (Keran 1978). In Ontario, uses young, deciduous-dominated forests with a mean canopy height of 21 m and mean elevation of 350.4 ± 48.8 (SD) m (Armstrong and Euler 1983). Conifer plantations used rarely (Crocoll 1984).

F. Tilly pers. comm.). Migrants dispersed more broadly along Atlantic slope in spring than in fall.

In Guatemala, large flights follow the foothills on the Atlantic slope (Land 1970). In Honduras, huge flocks reported during Oct on the Pacific slope (Monroe 1968). In Costa Rica, migrants appear to use both slopes in spring but primarily the Atlantic slope and highlands in fall (Stiles and Skutch 1989). In Panama, primary route is same as that used by Swainson's Hawk (near Pacific Coast in central Panama and in central mountains in east and west; Ridgely and Gwynne 1989). Migrants of both species occur in such large numbers in Panama that they "blacken the sky" (Ridgely and Gwynne 1989).

South of Panama there are few data on the routes (or flight timing). Thousands appear to roost along eastern slope of Colombian Cordillera in sites such as Combeima Canyon between Bogota and Cali (Bildstein et al. 1993).

Although most birds reach winter destinations via Texas and Middle America, possible limited over-water route; individuals observed flying south from Florida Keys in fall (e.g., Robertson and Ogden 1968), although some fly northwest, after having turned back from an extended over-water flight across the Florida Strait (e.g., Darrow 1983). Recher and Recher (1966) reported spring flights of *B. p. platypterus* over Puerto Rico, and others report flocks (e.g., 40–200 birds) on Tobago (Rowlett 1980; LJG), and Little Tobago (ffrench 1991). Occasional sightings on Trinidad (Hoffman and Darrow 1992). Migrants reported consistently but rarely from Dominican Republic (Martinez 1995).

TIMING OF MIGRATION

One of the earliest fall migrants of any North American raptor, and one of the latest in spring. Timing probably influenced by reliance on cold-blooded prey (Newton 1979; see Food Habits: diet, below).

Fall. In e. North America, fall migration mid-Aug to early Oct with peak flights (mid-Atlantic) 10–20 Sep (Haugh 1972, Bednarz et al. 1990). Breeders leave territories in New York and Pennsylvania in late Aug to mid-Sep (Matray 1974, 1976, Crocoll 1984, LJG) Timing of migration is compressed at any given latitude; e.g., at Hawk Mtn., PA, 95% of all fall migrants pass within a 2-wk period in mid-Sep (Bednarz et al. 1990). In s. Texas, major flights occur in late Sep and first week of Oct, with smaller flights continuing through late Oct (e.g., 1-day records of >250,000 birds in s. Gulf Coast); late migrants recorded into Nov.

Fall migration in Mexico occurs Sep–Oct with peak in late Sep or early Oct; peak 1-day flights of >400,000 recorded in central Veracruz (Ruelas Inzunza et al. 1993). Fall migrants recorded in Costa Rica and Panama from late Sep to mid-Nov, but most pass in Oct (Wetmore 1965, Smith 1980, Ridgely and Gwynne 1989, Stiles and Skutch 1989).

Birds begin to arrive on wintering sites by late Oct; appear widespread through Amazonia, Brazil, after 31 Oct (Smith 1985b, Stotz et al. 1992).

Spring. Spring migration spans the period Mar through May and, rarely, into Jun. Migrants recorded in Panama from Mar to early Apr, with most migration occurring mid- to late Mar (Wetmore 1965, Smith 1980, Ridgely and Gwynne 1989). Spring migrants recorded in Costa Rica from early Mar to late May (Stiles and Skutch 1989), with most passing in mid-Mar (Skutch 1945, Hidalgo et al. 1995).

In Mexico, migrants recorded from Mar to mid-May (Howell and Webb 1995), with peak flights last week of Mar to early Apr (Ruelas Inzunza et al. 1993). Birds then fly north into Texas by early Apr. Movements in Texas peak in the last week of Mar and the first 1–2 wk of Apr, with thousands of birds per day passing sites such as Santa Ana National Wildlife Refuge.

Spring migration peaks in mid- to late Apr from mid-Atlantic states north (Haugh 1972). Peak movements (>10,000 birds/day) along the south shore of the Great Lakes occur in late Apr and early May. Late migrants, predominantly subadults, often return to breeding areas in late May or Jun (Mueller and Berger 1965, Haugh 1972).

No known differences in migration pattern or timing by sexes. Few data on timing of fall migration by age, although observations at Hawk Mtn., PA, suggest that immatures may migrate earlier than adults (LJG). Immatures migrate north several weeks later than adults in spring, with peak flights of adults in Apr and of immatures in early May (Haugh 1972, Kerlinger and Gauthreaux 1985).

Geographic origins of overwinter populations. No association noted between origins of individuals and their winter recovery locations. U.S. Fish and Wildlife Service band recoveries for birds banded during the breeding season or fall migration and recovered between Dec and Feb (n = 22 [1926–1985]), showed 6 (27.3%) recoveries in South America, 10 (45.5%) in Central America, 2 (9.1%) in Mexico, and 4 (18.2%) in U.S. Recovery data may be biased toward U.S. recoveries.

Segregation on the wintering grounds among age and/or sex classes. A sample of 191 specimens from 14 scientific museums (see Appendix 4) suggests little if any segregation among age and sex classes on wintering grounds in s. Central America and nw. South America (SES). When birds wintering in Florida are included in this sample, juveniles appear to winter farther north than adults. South Florida wintering population may represent birds that have separated from the main flight (Tabb 1979). Three

Resident subspecies nest in older, continuous forests of West Indies (Wiley 1986).

Although generally nests away from human dwellings (Armstrong and Euler 1983), sometimes indifferent (Fitch 1974). Detected more frequently in undisturbed, mixed conifer-deciduous forests of Maine than in areas used for agriculture or forestry (Devaul 1990).

Compared to nesting Red-shouldered Hawks, uses younger forests with more openings (Titus and Mosher 1981, Armstrong and Euler 1983, Crocoll and Parker 1989). Breeding home range may overlap with that of Red-tailed Hawk (Fitch 1974, Fuller 1979).

SPRING AND FALL MIGRATION

Little known; migrant roosts reported only in wooded areas. Migrants roost on edges of evergreen and tropical semideciduous, tropical deciduous, and cloud forests, and in arid tropical scrub during migration through Oaxaca, Mexico (Binford 1989). Flocks of up to 35 individuals seen roosting in a single tree in Mexico and Central America (Smith 1980, Ruelas Inzunza et al. 1993). Nearly 19,000 roosted in a 12-km^2 forest area (Smith 1980). Elevations of 54 museum specimens collected during migration averaged 1,694 ± 817 (SE) m in South America and 1,096 ± 669 (SE) m in Middle America (SES).

WINTER RANGE

Winter range largely contained within the humid tropical ecoregion domain; forests of this region include seasonably humid mixed and deciduous forests, and a variety of rainforest habitats (Bailey 1989).

In Middle and South America, appears broadly tolerant in choice of winter habitats; may be found in a variety of forest types from mature tropical forest to second-growth, forest edges, and clearings (Terborgh 1980, Ridgely 1989).

In Panama inhabits forested areas in cultivated lands; usually seen perched in trees (Wetmore 1965). In South America, frequents partly open terrain, llanos, paramo, second-growth forest, coffee plantations, and forest borders; hunts in forest clearings (Meyer de Schauensee and Phelps 1978, Hilty and Brown 1986). Winters in older second-growth and Amazonian forest in Brazil and primary forest in Peru and Ecuador (Stotz et al. 1992, Robinson et al. 1995). Appears to establish winter territories (Slud 1964, Smith 1980; see Behavior: spacing, below).

In Florida Keys, uses undisturbed West Indian hardwood hammocks on the larger keys and extensive groves of mangoes and avocados in agricultural areas (Tabb 1973). Forages on forest edges and natural short grass glades.

May be found from sea level to several thousand meters throughout winter range (e.g., Slud 1964), but prefers upland sites (e.g., mountain foothills). In Honduras, mostly observed below 1,000 m (Monroe 1968). An analysis of 63 museum specimens (SES) collected in South and Middle America during winter (Dec–Feb) showed a mean elevation of 1,767 ± 277 (SE) m. Wintering elevation did not vary among age and sex groups (SES).

In Costa Rica and Panama, 2 other species may use habitat similar to wintering Broad-winged Hawk: Roadside Hawk (*Buteo magnirostris*) and Gray Hawk (*B. nitidus*). The former usually is found in drier, more open country than Broad-winged Hawk; the latter is much less common (Smith 1980) and forages in tree branches rather than on the ground as does Broad-winged Hawk (see Food Habits: feeding).

FOOD HABITS

FEEDING

Perch-hunts below the canopy and often near an opening, forest edge, or water body (Slud 1964, Crocoll 1984, Toland 1986). Occasionally hunts from flight, but rarely stoops (Burns 1911, Fitch 1974).

Main foods taken. Generalized predator, taking wide variety of food items; amphibians, insects, mammals, and juvenile birds the most common prey across North American range. Small mammals and amphibians are the most frequent prey and greatest biomass in most studies (Fitch 1974, Matray 1974, Crocoll 1984). Most prey are between 10 and 30 g body mass. Birds taken during breeding season are predominantly nestlings or fledglings (Rosenfield et al. 1984). Propensity for amphibians (mainly frogs and toads) may explain habitat association with water and migration schedule (Matray 1974, Crocoll 1984, Rosenfield et al. 1984). Insects taken opportunistically on migration and at wintering sites (Wetmore 1965, Shelley and Benz 1985).

Microhabitat for foraging. Perches on utility poles, wires, tree limbs, often at edges of forest openings (Crocoll 1984, Toland 1986). In winter, hunts from open branches in or below the canopy; perch height ranges from 10 to 20 m (Wetmore 1965, Buskirk 1976).

Food capture and consumption. Described as "cat-like" in pose when it spots prey and swoops down to snatch it from the forest floor (Burns 1911). Successful in 67% of foraging attempts observed in Missouri, with highest success shown for reptiles and invertebrates (Toland 1986). Buskirk (1976) lists the wintering Broad-winged Hawk as a "sentinel forager," spending large proportions of its time sitting quietly, scanning for prey. Adults tend to hunt more after midmorning; prey deliveries to nestlings increase through the day (Fitch 1974).

Mammal prey fully consumed, large snakes and frogs skinned. Birds are often plucked (Burns 1911, Brown and Amadon 1968). In captivity, food consumption increases with food deprivation interval, up to 12 h; captives kill more mice at first feeding of the day than at last (Mueller 1973). Captive birds do not kill additional mice after sated (Mueller 1973).

DIET

Major food items and quantitative analysis. Diet depends on local availability of prey (Appendix 1). Short-tailed shrew (*Blarina brevicauda*), eastern chipmunk (*Tamias striatus*), and American toad (*Bufo americanus*) the most frequent prey at w. New York breeding sites (Crocoll 1984). Proportion of prey types delivered to New York nests (n = 13): 46% mammals, 26% birds, 14% amphibians, 14% reptiles. Insect prey difficult to ascertain, but suspected (Crocoll 1984). In Adirondack Mtns., NY, diet 35% mammals, 35% amphibians, 20% birds, 10% reptiles (Matray 1974; see Appendix 1).

In Alberta, Canada, nestlings fed mostly mammals (see Appendix 1); red-backed vole (*Clethrionomys gapperi*) and meadow vole (*Microtus pennsylvanicus*) the most numerous items taken, with Ruffed Grouse (*Bonasa umbellus*) chicks forming largest component of avian prey (Rusch and Doerr 1972).

Insects and other invertebrates reported (54–80% occurrence) from stomach analyses (e.g., Snyder and Wiley 1976), but level of importance in diet unclear. Nest and stomach contents from virgin woodland included "unknown quantities of insects" including maybeetles and beetles (Coleoptera), along with small birds, mammals, and a snake (Errington and Breckenridge 1938). Other invertebrates reported in various studies include moths, wood ants (Formicidae), Junebugs (*Phyllophaga* sp.), canthon click beetles (Elateridae), ground beetles (*Harpalus*), Diptera, Lepidoptera larvae, spiders (Arachnida), and earthworms (Lumbricidae). Orthoptera (crickets, grasshoppers, and mantises) is the most heavily represented group across all studies (Burns 1911, Errington and Breckenridge 1938, Brown and Amadon 1968).

Unusual prey reported include Northern Saw-whet Owl (*Aegolius acadicus*) and Northern Flicker (*Colaptes auratus*) (Rosenfield 1979). Diet overlap with Red-tailed Hawk estimated to be 25%, but Broad-winged Hawk takes smaller items, on average: 19 versus 106 g (Fitch 1974).

Wintering Broad-winged Hawks feed on large insects, snakes, lizards, frogs, crabs, and small mammals (e.g., cotton rats [*Sigmodon hispidus*], mice); less frequently on birds (Burns 1911, Slud 1964, Wetmore 1965, Meyer de Schauensee and Phelps 1978). In Cuba, one bird ate minnows (J. Mosher *in* Palmer 1988).

More data needed on diet and feeding during migration. Insects, particularly Orthoptera and Lepidoptera, may be important food sources for this long-distance migrant (Shelley and Benz 1985).

FOOD SELECTION AND STORAGE

Food caching rarely recorded but may occur frequently; in one study, females returned after brief absences with a partly consumed prey resembling the one removed the day before, although no actual cache sites located (Matray 1974). A dead Broad-winged Hawk nestling was cached near the nest site and brought back to the nest for 2 feedings (Lyons and Mosher 1982).

NUTRITION AND ENERGETICS

Digestive efficiency (metabolizable energy/energy intake) of 7 captive Broad-winged Hawks averaged 74% (range 72–79%; Mosher and Matray 1974). Caloric value (percent kilocalaries) gained from prey brought to nest: 27% for amphibians, 25% for reptiles, 8% for birds, 41% for mammals (n = 333 prey items). Average energy/prey item available to bird estimated at 30.8 kcal. Average of 136 kcal/d delivered at 2 nests (Mosher and Matray 1974), with mean metabolizable energy consumption rate of 103 kcal/d. Average energy value of prey delivered to nestlings at 3 nests ranged from 155 to 112 kcal/d/nestling (Mosher and Matray 1974).

Food stress during feather development may be one cause of fault bars in feathers. Data recorded from 8 museum specimens showed that 22% of rectrices and 7% of primaries had heavy fault bars with an average (± SD) of 3.0 ± 5.1 bars in rectrices of adults and 2.8 ± 2.1 bars in rectrices of juveniles (Hawfield 1986).

METABOLISM AND TEMPERATURE REGULATION

Not well studied. Captive males and females do not differ in mean daily metabolic rate/g. For 4 females, mean daily metabolic rate 0.197 kcal/g; for 3 males, 0.198 kcal/g; combined daily rate (n = 7) 0.198 kcal/g, or 81.7 kcal/bird. Resting metabolic rate predicted to be 0.19 kcal/g/d (Mosher and Matray 1974).

Smaller male thus appears to need less total energy than female at same level of activity. Mosher and Matray (1974) estimate that energy saving for pair increases as male activity increases. Because male is primary food provider during incubation and early brooding, this may represent a selection factor for dimorphism. Estimated energy saving for pair is equivalent to 17–23% of daily requirements (Mosher and Matray 1974).

most of the year, except during migration when ≥15 birds observed in 1 tree (Slud 1964, Fitch 1974, Smith 1980).

Daily time budget. Few data available. Appears to forage more in afternoons (Fitch 1974). Three radio-tracked birds spent most of time preening, feeding, and roosting; activity level less for nonbreeding male (Fuller 1979). See also Breeding: incubation, below.

AGONISTIC BEHAVIOR

Few data. Defends home range from conspecifics and reacts aggressively to Red-tailed Hawks during breeding season (Keran 1978, Armstrong and Euler 1983). Interspecies encounters with Red-tailed Hawks observed with 1 or 2 of each species soaring and swooping at each other. Interactions may be reduced by Broad-winged Hawk's habit of perching concealed in foliage, and using more forested areas (Fitch 1974, Preston and Beane 1993). No clearcut aggression observed toward a Red-shouldered Hawk with overlapping range (Fitch 1974), although Burns (1911) reports a Broad-winged Hawk attacking this species during the breeding season.

In 14 of 90 instances, breeding Broad-winged Hawks responded to taped call playbacks (*peeeurr* calls; see Sounds: vocalizations, above) by vocalizing and flying low toward call location (Balding and Dibble 1984).

SPACING

Distance between Broad-winged Hawk nests greater (1,441 ± 331 m [SD], $n = 11$) than between nests of this species and Red-shouldered Hawk (877 ± 422 m, $n = 12$; Crocoll and Parker 1989). In Wisconsin, distance between Broad-winged Hawk nests varies among years (mean ± SD 1976: 1,500 ± 370 m; 1980: 1,700 ± 720 m; 1981: 1,100 ± 620 m [Rosenfield 1984]). During breeding season, female discourages presence of male at nest after prey delivery (Matray 1974). A nonbreeding male used parts of the range of a breeding pair (Fuller 1979).

Territoriality. Little studied. Said to establish home range relatively quickly after arrival from migration (Fitch 1974).

Few data in winter; appears solitary and may maintain feeding territories (Slud 1964, Wetmore 1965, Tabb 1973, Buskirk 1976, Smith 1980).

SEXUAL BEHAVIOR

Mating system and sex ratio. Presumably monogamous. No information on sex ratio.

Pair bond. Needs further study. A pair trapped near same nest site during 2 succeeding years suggests pair bond can last >1 yr in some pairs (Matray 1974); however, other pairs take new mates between years (K. Titus pers. comm.).

Courtship Displays. Three types of courtship flights observed; both male and female call and respond during courtship (Burns 1911). (1) High Circling. This advertising display begins immediately after arrival. Birds are conspicuous and noisy, emitting *peeeurr* call. One bird, presumably male, sideslips or dives downward very close to touching the other, presumably female (Bent 1937, J. Mosher *in* Palmer 1988). (2) Sky-dancing. Bird leaves perch, flapping upward in widening circles, calling. Then with spread wings and tail soars lightly back and forth, still going upward until nearly lost from sight. Then "descends with long sweeps and curves, terminating with long dash" horizontal to ground (J. Mosher *in* Palmer 1988). (3) Tumbling. Circling bird drops toward earth checking its headlong course just before reaching the ground (J. Mosher *in* Palmer 1988).

Courtship Feeding. Incidence of courtship feeding needs further study. In one pair, a bird (presumably male) brought prey regularly to mate during nest construction (Bush and Gehlbach 1978); for another pair, prey delivered during incubation (Burns 1911).

Copulation. Copulation behavior starts with male and female perched apart. Male calls a 2-note *wheeooou*, then flies to female. Female turns away. Male alights on her back and copulates for a full minute calling throughout. Male maintains balance by half-flaps of wings, then flies to another nearby tree (Bent 1937, STC). A captive bird exhibited similar behavior toward a researcher; landed on researcher's arm to copulate with toes balled up, resting weight on the entire tarsometatarsus (Mueller 1970).

Extra-pair copulations. None known.

SOCIAL AND INTERSPECIFIC BEHAVIOR

Degree of sociality. During breeding season, pairs appear to be solitary with no social interaction among pairs (see Spacing: territoriality, above). Aggregates during migration (see Migration: migratory behavior, above). Flocks may contain other raptors (see Migration). In winter, solitary and territorial (e.g., Slud 1964, Tabb 1973, Smith 1980).

Play. Unknown.

Nonpredatory interspecific interactions. Needs further study. Songbirds (see Food Habits: diet, above) sometimes show aggressive response to the presence of adults (Burns 1911, STC). Observed to nest near Cooper's Hawk, Sharp-shinned Hawk (*Accipiter striatus*), Red shouldered Hawk, Red-tailed Hawk, Barred Owl (*Strix varia*), Long-eared Owl (*Asio otus*), and American Crow (*Corvus brachyrhynchos*) (Burns 1911, Fitch 1974, Crocoll and Parker 1989, J. Mosher pers. comm.). Breeding Cooper's Hawk attacked Broad-winged Hawk when they were nesting <100 m apart (K. Titus pers. comm.). Also see Spacing, above.

Defends nest area against Red-shouldered Hawk,

DRINKING, PELLET-CASTING, AND DEFECATION

From Duke et al. 1976. Meal-to-pellet interval measured for 2 captive Broad-winged Hawks averaged 22 ± 0.5 (SD) h when fed at 0900 h; when fed at 1100 h, interval shortened slightly. Size of the meal did not affect casting interval or pellet size; casting may be related to onset of dawn. When captive birds were fed laboratory mice ad libitum, they egested 1 pellet for every 2 meals. Food consumption declines prior to casting.

SOUNDS

VOCALIZATIONS

Development. Nestlings emit peeping cry at hatching. One nestling gave a *chic-chic-chic* defensive cry when disturbed (Palmer 1988). A hungry, older nestling emitted a shrill *cheeeee* (Burns 1911). Fledglings emit characteristic adult whistle (see below) after 30–36 d (Matray 1974).

Vocal array. Characteristic call is a 2- to 4-s high-pitched whistle described as *peeeurr*, *kee-eee*, or *peeoweee*, with first note short and higher-pitched than second (Burns 1911, Bent 1937, Matray 1974; see Fig. 3). This vocalization is given on the nest, also in flight, throughout the year. Male's call is 1 octave higher-pitched than female's. A hand-reared adult, taken from nest at 2 wk of age, emitted this call on copulation (Mueller 1970), suggesting that learning is not necessary.

Other calls recorded: (1) Transfer Call, a series of whines given by adults during food transfers, and at a more frenzied pitch by fledglings when parents bring food to nest; (2) Dismissal Call, given by female when male is approaching or leaving the nest; a more plaintive variation of the standard whistle (Matray 1974); and (3) a call described by Mueller (1970) as a wheezy 2-tone whistle (*whee-ohh*) emitted on copulation. Burns also notes a distress cry of *ka-ka-ka-ka* given by female protecting nest from grackles (*Quiscalus* sp.; Burns 1911).

Social context and presumed functions of vocalizations. See above. Typical whistle given in wide variety of locations and all seasons (Burns 1911, Palmer 1988). May have multiple functions. Tape-playback experiments during breeding season in Wisconsin elicited a response in 14 of 61 high-decibel playbacks (Balding and Dibble 1984). More likely to respond to call of conspecific than to call of a Red-tailed or Red-shouldered hawk. Behavior suggests possible territorial function both within and between species. Most other calls seem to serve as communication within a pair or family group.

NONVOCAL SOUNDS

None reported.

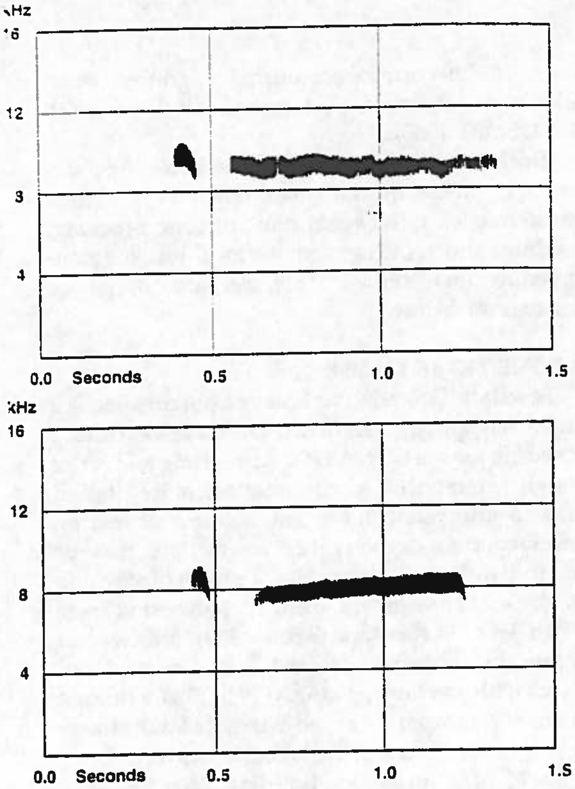

Figure 3. Typical vocalizations of Broad-winged Hawk. Top: adult in flight (recorded 9 May 1988; Borror Laboratory of Bioacoustics [BLB]#16937). Bottom: adult perched, 24 Jun 1963; BLB# 6507).

BEHAVIOR

LOCOMOTION

Moves within forest with short flights of <10 m from branch to branch; flies above forest using soaring and flapping flights. Often soars in circles above the forest during breeding season; probable territorial function (Burns 1911). See also Migration: migratory behavior, above.

Morphology appears well designed for soaring. Aerodynamic performance measured by radar revealed a turning radius on 30° bank angle of 11 m, air speed in a glide of 11.6 m/s, cruising speed of 24.2 m/s (Kerlinger 1982). During on-ridge migration, appears to glide predominantly (95%). Air speed of birds using ridge updrafts averaged 13.7 m/s (range 10.5–24.5 m/s), and birds flew faster with strong ridge lift (Broun and Goodwin 1943). Birds traveling in thermals averaged 24.2 m/s during interthermal glides (Kerlinger 1989).

SELF-MAINTENANCE

Preening, head-scratching, stretching, bathing, anting, etc. Few observations available. Juveniles begin preening at 14 d; females do not preen nestlings, but do remove insects (Matray 1974).

Sleeping, roosting, sunbathing. Not described. Appears to roost alone beneath the canopy during

Red-tailed Hawk, and Northern Harrier (*Circus cyaneus*) (Fitch 1974, Armstrong and Euler 1983, J. Mosher *in* Palmer 1988, STC).

PREDATION

Not well documented; eggs and nestlings most vulnerable. Raccoon (*Procyon lotor*) and porcupine (*Erethizon dorsatum*) eat eggs and nestlings; American Crows take eggs (Rosenfield 1984, K. Titus pers. comm.). Black bear (*Ursus americanus*) destroyed a nest with small young in Ontario (Blomme 1983).

In w. New York, predation accounted for 50% of nests destroyed, usually before hatching (n = 10; Crocoll and Parker 1989). Great Horned Owl (*Bubo virginianus*) responsible at most nests, killing incubating adults. One report of predation outside the breeding season: immature Bald Eagle (*Haliaeetus leucocephalus*) killed an immature Broad-winged Hawk in Florida in early winter (Brown 1986). No response to nonhuman predators recorded; individuals known to be aggressive to humans at nest (STC), although apparently uncommon (e.g., 3 of 150 visits; J. Mosher *in* Palmer 1988).

BREEDING

PHENOLOGY

Pair formation. Figure 4. Little studied. In Kansas, pair formed within 1 wk of arrival, 19–25 Apr (Fitch 1974). In Texas, at a single nest, a single pair was present within 1 wk of a large migratory flock passing through the area (Bush and Gehlbach 1978). Few data on resident subspecies.

Nest-building. Takes 2–4 wk (J. Mosher pers. comm.); in w. New York, generally about 3 wk (third week in Apr through mid-May; Crocoll and Parker 1989) but may extend for 5 wk (Bent 1937, Matray 1974). Construction completed by mid-May in Adirondack Mtns., NY (Matray 1976), and Texas (Bush and Gehlbach 1978). In Kansas, nest construction quite rapid (1 wk), occurring in third week of Apr (Fitch 1974). Nest-building observed early May to mid-Jun in Ontario (Armstrong and Euler 1983).

First/only brood per season. About 1 mo difference between dates of clutch completion in southern and northern part of range. Egg-laying as early as late Apr in Kansas (Fitch 1974); first week in May in Washington, D.C. (Burns 1911), and Maryland (Janik and Mosher 1982); mid- to late May in Ontario (Burns 1911, Armstrong and Euler 1983); first week of Jun in Alberta (Rusch and Doerr 1972).

Incubation period 28–31 d (Matray 1974, Bush and Gehlbach 1978; see Fig. 4). Hatching generally second to third week of Jun (Matray 1974, Bush and Gehlbach 1978, Janik and Mosher 1982, Crocoll and Parker 1989), except in Kansas (1–10 Jun; Fitch 1974) and Alberta (mean = 2 Jul; Rusch and Doerr 1972).

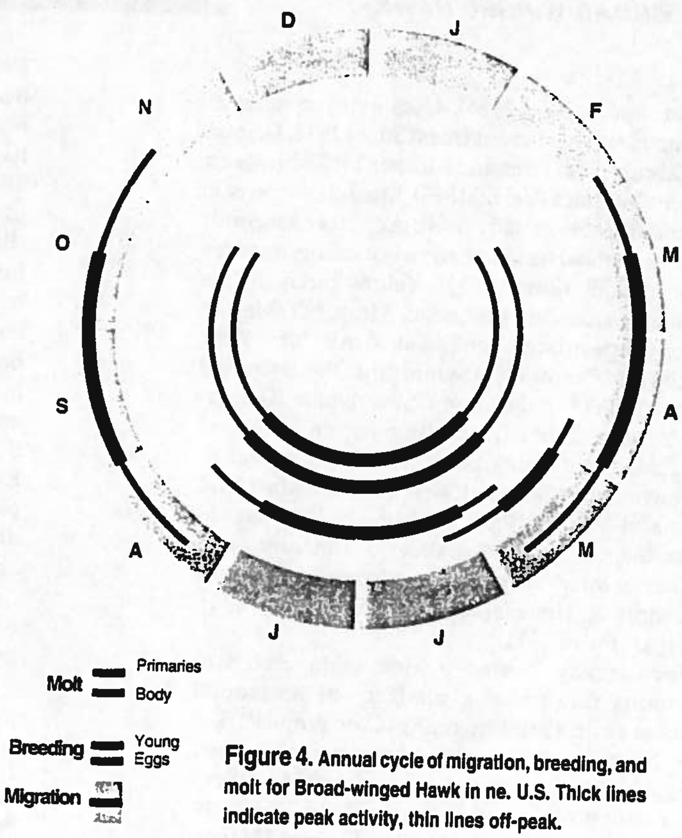

Figure 4. Annual cycle of migration, breeding, and molt for Broad-winged Hawk in ne. U.S. Thick lines indicate peak activity, thin lines off-peak.

Young leave nest between late Jun and first week of Aug, earlier in southern portion of range, later in northern (Fitch 1974, Matray 1974, Bush and Gehlbach 1978, Keran 1978, Janik and Mosher 1982, Armstrong and Euler 1983, Crocoll and Parker 1989). Young last observed being fed 16 Aug at a nest in Adirondack Mtns., NY, and last observed in area of nest on 23 Aug (Matray 1974). Adults and young both disperse in Aug; in some areas (e.g, Texas; Bush and Gehlbach 1978), adults depart first; in others (New York; Matray 1974), young depart first.

Caribbean subspecies reported to nest between Mar and Jul (Evans 1990).

NEST SITE

Selection process. Unknown which sex selects nest site. Pairs sometimes reuse nests in subsequent years (20% in Adirondack Mtns., NY [Matray 1974]; 7% in Wisconsin [Rosenfield 1984]; 33% in w. New York [Crocoll and Parker 1989]). May renovate old nests of other species (Burns 1911).

Site characteristics. Usually nests in deciduous or mixed deciduous-coniferous forest (Burns 1911, Bent 1937; see Habitat: breeding range, above). In Pennsylvania, found in conifer-dominated forest

(Grimm and Yahner 1986). Uses many species of deciduous and coniferous trees (Burns 1911, Grimm and Yahner 1986, Titus and Mosher 1987). Nests on cliffs on Dominica (Verrill 1893). Most characteristic tree in a forest is usually used; American chestnut (*Castanea dentata*) was formerly a typical nesting tree in the ne. U.S. (Burns 1911). Yellow birch (*Betula alleghaniensis*) used in Adirondack Mtns., NY (Matray 1974); European larch (*Larix decidua*) in w. New York (Crocoll and Parker 1989); white pine (*Pinus strobus*) and red pine (*P. resinosa*) in Pennsylvania (Grimm and Yahner 1986); trembling aspen (*Populus tremuloides*) and white birch (*Betula papyrifera*) in Wisconsin, and white oak (*Quercus alba*) in Maryland (Titus and Mosher 1987). Nest height, diameter at breast height (DBH), distance to wet area, and distance to forest opening vary among populations (Appendix 2). Unusual nest heights of 1 and 27 m recorded (Burns 1911).

Nest usually located in first main crotch of deciduous tree or on a platform of horizontal branches against trunk in conifer (Crocoll and Parker 1989). Nest placed in lower third of canopy. Number of branches supporting nest varies from 2 to 5 (Bent 1937, Keran 1978, Crocoll and Parker 1989). Throughout its range of sympatry with Broad-winged Hawk, Red-shouldered Hawk generally nests in larger trees, higher in the tree, farther from a forest opening, and on more level ground (Crocoll 1994). Broad-winged Hawk, however, nests higher in w. Maryland (Titus and Mosher 1987) and farther from openings in Ontario (Armstrong and Euler 1983).

NEST

Construction process. Both sexes help construct nest, although female does most work (Burns 1911, Matray 1974). Dead sticks used in structure; obtained from ground and carried in talons (Burns 1911, Matray 1974). Fresh sprigs and bark chips for nest cup brought exclusively by female in beak (Matray 1974, Rosenfield 1984). Before incubation, active nests identified by fresh conifer sprigs (Matray 1974, Crocoll and Parker 1989). Green sprigs placed on nest rim or cup are not incorporated into the nest (Lyons et al. 1986, STC). Deciduous sprigs are broken from lower halves of trees and carried in beak to the nest (Rosenfield 1982). Compared to nest of Red-shouldered Hawk, structure is crude (Burns 1911).

Refurbishing of old nests seen in some populations (Burns 1911, Matray 1974, Rosenfield 1984, Crocoll and Parker 1989). Of nests of known age, 33% (n = 15) reused ≥1 yr in w. New York (Crocoll and Parker 1989); 20% (n = 10) in Adirondack Mtns., NY (Matray 1974); and 7% (n = 72) in Wisconsin (Rosenfield 1984).

Structure and composition matter. Nests built of fresh twigs and old dead sticks of many species of deciduous trees (Burns 1911). Twig length ranges from 10 to 40 cm. Nests may be placed on old crow, hawk, or squirrel nests (Burns 1911). Nest cup almost always lined with bark chips (2.5–15 cm long) from many species of deciduous and coniferous trees (Burns 1911, Matray 1974, Lyons et al. 1986). Corn husks, moss, inner tree bark, red cedar (*Juniperus virginiana*), wild grape vine, lichen (*Usnea* sp.)-covered bark, chicken feathers, or pine needles occasionally found in lining (Burns 1911, J. Mosher *in* Palmer 1988). Fresh green sprigs added shortly after nest construction begins (Lyons et al. 1986, STC). Sprig delivery observed from before incubation to 26 d posthatching (Lyons et al. 1986). From time of egg-hatching, average of 3.2 sprigs delivered/day, 83.2 sprigs for entire nestling period (Lyons et al. 1986).

Dimensions. Outside diameter 30–53 cm, outside height 12–30 cm, inside diameter 15–18 cm, inside depth 2–8 cm; flattest nests in pines (Bent 1937).

Microclimate. No data. Nests usually at least partially shaded (STC).

Maintenance or reuse of nests; alternate nests. Nest reuse not uncommon (see Nest Site: selection process, above), but typically builds a new nest (Burns 1911, Matray 1974, Rosenfield 1984, Crocoll and Parker 1989). Territories often hold several nests, suggesting territory reuse over several years (K. Titus pers. comm., STC). Only active nests have fresh green sprigs (STC). Refurbishing may yield an energy savings over constructing a new nest. In w. New York, pairs that reused nests fledged fewer young than those that built new nests (Crocoll and Parker 1989).

EGGS

Shape. Usually short elliptical, with some long elliptical (C. Preston pers. comm.).

Size. Limited data for subspecies, except nominate *B. p. platypterus*. Mean length and breadth (mm) 49 x 39 (n = 509; Burns 1911); 48.9 x 39.3 (n = 51; Bent 1937); 49.04 ± 1.90 SE x 39.17 ± 1.19 SE (n = 20 [Connecticut 5, Pennsylvania 12, New Hampshire 2, Michigan 1]; C. Preston pers. comm.); 49.59 (46.37–54.52) x 39.60 (37.06–41.74) (n = 48; Western Foundation of Vertebrate Zoology [WFVZ]); 49.72 ± 1.63 (SD) x 38.90 ± 0.96 (n = 30 in w. New York; STC). No consistent geographical variation in size among *B. p. platypterus* eggs. *B. p. rivieri*: 45.7–51.5 x 38.1–39.5 mm (n = 5; WFVZ). *B. p. antillarum*: 47.4–50.4 x 37.7–39.1 mm (n = 4; WFVZ).

Mass. Fresh egg weight 42–43 g (J. Mosher *in* Palmer 1988). Using average female weight of 437 g (Mosher and Matray 1974), 1-egg clutch = 6.8% of adult female mass (n = 1), 2-egg clutch = 15.4% (n = 2), 3-egg clutch = 25.3% (n = 6), 4-egg clutch = 34.9% (n = 1) (STC); For 3-egg clutches (n = 18) in w.

New York, difference in size (volume) among eggs not significant (STC).

Color. Ground color white, pale creamy, or slightly bluish. Markings frequently in 2 layers varying from large patches to tiny dots. Markings various browns. Sometimes underlying markings various lavenders (J. Mosher *in* Palmer 1988). Eggs of *B. p. antillarum* dull bluish white and unspotted (Clark 1905); eggs of *B. p. rivieri* dull white, heavily spotted with various browns (Verrill 1893).

Surface texture. Granulated, without gloss.

Eggshell thickness. Pre-DDT (1947): thickness 0.328 mm (range 0.286–0.363, *n* = 48; WFVZ).

Clutch size. See Demography and Populations: measures of breeding activity, below.

Egg-laying. Interval 1–2 d. Replacement clutches are known (Burns 1911).

INCUBATION

Onset of broodiness and incubation in relation to laying. Incubation usually begins with first egg, occasionally with second egg in 3- or 4-egg clutches (Crocoll and Parker 1989).

Incubation patch. Female only. A single large patch covering the ventral abdominal and thoracic regions (Matray 1974). Down present on edges of nest during this period probably emanates from this area.

Incubation period. 28–31 d (Matray 1974, Bush and Gehlbach 1978).

Parental behavior. Males provide food; females do most of incubating. At 2 nests in Adirondack Mtns., NY, females attended nest 92% of time during day, males 5%; nests unattended 3%. Length of time female was in attendance varied from a few seconds to >8 h. Females also appeared to do most or all of nocturnal incubating (Matray 1974).

In one Texas nest, no incubation when air temperature >30° C (approximately 1300–1500 h), but regularly incubated between 0700 and 1030 h and from 1700 until dusk, when cooler (Bush and Gehlbach 1978). Male may be capable of completing incubation if female dies (Burns 1911).

Male visits nest only after transferring food to female away from nest. Female whines (see Sounds: vocalizations, above), then male presumably transfers food, but this has not been observed. Afterward, male quickly comes to nest to incubate. Male usually remains at nest until relieved by female, although occasionally leaves to bring nesting material (Matray 1974). Female usually returns within 15 min, then male departs either before or just after her return (Matray 1974). Female calls before returning (Matray 1974; see Sounds: vocalizations). Female inattentive periods associated with one of the following activities: feeding, collecting nesting material, or defecating (Matray 1974).

Hardiness of eggs against temperature stress. Longer attentive periods of female often associated with rain and cool temperatures (Matray 1974), suggesting that eggs are susceptible to adverse weather, particularly in northern portion of range.

HATCHING

In w. New York, eggs hatch 1 d apart in 2-egg clutches (*n* = 4), 2.00 ± 1.41 (SD) d in 3-egg clutches (*n* = 24); in 3-egg clutches, second egg hatched 0.38 ± 0.52 (SD) d (*n* = 8) after first, third egg 2.62 ± 0.74 (SD) d (*n* = 8) after second (Crocoll and Parker 1989). In w. Maryland, eggs hatch asynchronously over a 1- to 4-d period (Lyons and Mosher 1987).

YOUNG BIRDS

Condition at hatching. Few data. Young semialtricial. Hatch with eyes open. Covered with thick prepennae white down, basally grayish (Bent 1937, Lyons and Mosher 1987). Mass 26–30 g (Fitch 1974, STC). Utter 2-note *peep* after hatching (Burns 1911, STC). At 1 d, legs turned in, unable to grasp objects, cannot raise body or wings but can raise head and will bite actively and at contact (Burns 1911, STC).

Growth and development. Maximum growth rate for bill at 1.5 d, tarsus at 7.8 d, body mass at 10.6 d (*n* = 33; Lyons and Mosher 1987). Primaries and first contour feathers appear at 9 d. Wing length and primary length at maximum growth on 19–22 d, by which time bill, tarsus, and body mass have attained 90% of asymptotic sizes (Lyons and Mosher 1987). Rectrices emerge 2–4 d after primaries and attain maximum growth on day 25 (Lyons and Mosher 1987). Mass at nest departure 371 ± 33 (SD) g (*n* = 26; STC).

MOLT INTO JUVENAL PLUMAGE. Primaries and secondaries appear first, followed by feathers on caudal, humeral, spinal, ventral, and capital tracts (Lyons 1983). Remiges appear at about 9 d of age (Fitch 1974, Lyons and Mosher 1987, STC). Rectrices appear at 11–13 d in Maryland (Lyons and Mosher 1987), 12–16 d in w. New York, except for one starved nestling 22 d (STC). At 21 d, still downy on head, neck, central breast, and belly (Bent 1937). Juvenal feathering complete at 43–51 d (Burns 1911, Lyons 1983; for more details, see Burns 1911 and Appearance: molts and plumages, below).

CONTROL OF BODY TEMPERATURE. Based on 2 nestlings. Rectal temperature, taken between 4 and 9 d, 38.7°C ± 0.6 SD (*n* = 8); between 20 and 22 d, 41.7°C ± 0.3 SD (*n* = 7; Fitch 1974).

BEHAVIOR AND LOCOMOTION. Maryland, first 9 d: 97% of time spent lying down. Head-droop-sleep and parental feeding are predominant activities of young (Lyons and Mosher 1987). Sit erect by 5–8 d (Burns 1911); actively orient toward parent's bill, reach forward and grab food morsels. All sleeping at this stage in head-droop-sleep posture (Lyons and Mosher 1987). Able to scratch self and disgorge hazelnut-size pellet by 5–8 d (Burns 1911). At 10–15 d, head-tuck-sleep posture first appears. Between 10 and 31 d, standing replaces lying as predominant behavior (Burns 1911, Fitch 1974, Matray 1974, Lyons and Mosher 1987). Preening (Matray 1974) and ability to defecate clear of nest (Rosenfield et al. 1982) occur at about 14 d. Poorly coordinated walking first performed at 8–10 d, mastered by 18–20 d (Lyons and Mosher 1987). Attempt to pick up and tear food between 13 and 17 d. Successful tearing of food and self-feeding between 20 and 28 d (Holt 1959, Matray 1974, Lyons and Mosher 1987). Fighting over food and mantling of prey during week 4 (Matray 1974, J. Mosher *in* Palmer 1988).

Fighting more frequent and violent in 3-nestling versus 2-nestling broods, but not well studied. In w. New York, brood reduction occurred at only 3 of 11 nests (STC). Sibling aggression uncommon (10% of nest observations); occurred equally in nests with and without brood reduction (STC). Aggression usually occurs before age 11 d; older young most often the aggressor.

Oldest nestling usually secures prey and feeds until sated, after which remaining nestlings feed (Matray 1974). Young first leave nest at 29–31 d (Matray 1974, Lyons and Mosher 1987). First flight 31.4 d (range 29–39 d, $n = 11$; Crocoll and Parker 1989), able flyers by 6 wk (Matray 1974). From first flight to approximately age 7 wk, spend most time perched on branches near nest or in trees near nest tree (Matray 1974, 1976, Lyons and Mosher 1987). Around 6 wk of age, young intercept parents away from nest to obtain prey; begin to capture own prey at 7 wk (Matray 1976). Fear of humans shown at 18–26 d (Burns 1911, Fitch 1974).

PARENTAL CARE

Brooding. In Adirondack Mtns., NY, almost continuously during first week (88% of time); by female exclusively. Rain brings female back to nest. Brooding ends 21–24 d posthatching (Matray 1974). In Maryland, brooding by female declined steadily with age of nestlings; 4–6 d, 86%; 7–9 d, 65%; 10–12 d, 56%; 13–15 d, 45%; 16–18 d, 34%; 19–21 d, 13%; 22–24 d, 6%; 25 d on, 0% (Lyons and Mosher 1987).

Feeding. Only female feeds young; male brings prey to her away from nest or drops prey on nest if female is absent (Matray 1974). Female tears up prey and feeds young; will pick up dropped pieces and offer again. Feeding continues for first 2–3 wk (Holt 1959, Matray 1974). Each feeding bout lasts approximately 9 min (range 2–50, $n = 94$), with 4–16 deliveries/day in New York (Matray 1976), average 1.94 deliveries/day over first 5 wk in Kansas (Fitch 1974). Occasionally >1 prey item fed to young at a single bout; this is usually the result of male depositing a prey item at nest when female is absent (Matray 1974). Prey delivered throughout the day but most delivered between 1000 and 1500 h (Matray 1974). Females spend 12–17% of time at nest feeding young between 4 and 12 d, 3–9% between 13 and 31 d (Lyons and Mosher 1987). Females begin hunting after nestlings 1–2 wk old.

In most areas, mammals are predominant prey brought to young; also nestling birds and invertebrates (Burns 1911; see Appendix 1). American toads are most common amphibian delivered to nests. In Kansas, >60% of prey between 10 and 30 g (Fitch 1974). Average energy value of prey delivered to each nestling for 3 nests = 137 kcal/d; for one 3-nestling brood, 112 kcal/d; and for 2 broods of 2 and 3 nestlings, respectively, 155 kcal/d (Mosher and Matray 1974). Uneaten prey may be cached, including dead nestlings (Lyons and Mosher 1982, 1987) (see Food Habits: food selection and storage, above).

Nest sanitation. Adults observed to eat nestlings' feces until young able to defecate clear of nest, at about 14 d (Rosenfield et al. 1982). Females remove uneaten prey from nest until near fledging, after which prey remains are left in nest (Holt 1959, Matray 1974, STC).

Parental carrying of young. Not known to occur.

COOPERATIVE BREEDING

Not known to occur.

BROOD PARASITISM

Not known to occur.

FLEDGING STAGE

Departure from the nest. Young first leave nest at about 5–6 wk of age (Burns 1911, Fitch 1974, Matray 1974, Lyons and Mosher 1987, Crocoll and Parker 1989). After that, young stay on territory 4–8 wk (Matray 1976, Bush and Gehlbach 1978). Fledglings observed using nest as feeding and roost site up to 2 wk after first flight (Holt 1959).

Growth. See Young Birds: growth and development, above.

Association with parents or other young. Little studied. Will stay on territory with siblings and adults up to 8 wk after fledging (Matray 1976, Bush and Gehlbach 1978).

Ability to get around, feed, and care for self. Begin capturing own prey at about 7 wk of age (3 wk after leaving nest). Flying skills develop rapidly. Intercept parents to obtain prey at about 6 wk (Matray 1976). Fledglings learn to hunt on their own (Matray 1976; see Young Birds: growth and development, above).

IMMATURE STAGE

Little studied. After first flight, young observed with parents up to 4 wk ($n = 1$ nest; Bush and Gehlbach 1978) and near nests up to 8 wk (Matray 1974, Bush and Gehlbach 1978, Lyons and Mosher 1987, STC). Much of the time within 2 wk of fledging spent perched close to nest, often returning to nest for parental food delivery (Lyons and Mosher 1987, STC). In Adirondack Mtns., NY, young begin hunting soon after leaving nest (Matray 1974).

DEMOGRAPHY AND POPULATIONS

MEASURES OF BREEDING ACTIVITY

Age at first breeding; intervals between breeding. Usually does not breed until ≥1 yr old, but yearlings reported breeding with adults on occasion (Burns 1911, Crocoll and Parker 1989). Males more commonly reported as yearling breeders than females. Yearling male-adult female pairs ($n = 10$) composed 40% of one w. New York breeding population in one year (Crocoll and Parker 1989).

Individuals probably attempt to breed every year (Crocoll and Parker 1989), although data are limited (see Rusch and Doerr 1972). In the only study where adults were banded, 1 of 2 pairs returned to nest within 400 m of the previous nest (Matray 1974).

Clutch. Varies geographically; appears to show a trend toward increasing from south to north, but sample sizes small (Burns 1911, Western Foundation of Vertebrate Zoology [WFVZ]). Range 1–4, usually 2 or 3. Clutches of 5 recorded but rare (WFVZ). Mean clutch size for 70 Wisconsin nests = 2.36; mean clutch ranged from 2.7 ($n = 15$) in Maryland to 2.2 ($n = 12$) in Minnesota and Wisconsin (Keran 1978, Janik and Mosher 1982, Rosenfield 1984, Crocoll and Parker 1989). Only data for Caribbean forms are for *B. p. rivieri*: mean 2.2 ($n = 5$; WFVZ). Also known to vary between years in the same study area (Rosenfield 1984, Crocoll and Parker 1989), with prey availability a likely cause. One clutch/year. In one study, a replacement clutch was laid when first was destroyed (Burns 1911).

Annual and lifetime reproductive success. No information on lifetime reproductive success. Annual fledging success varies from 1.5 ($n = 16$) to 2.00 ($n = 5$) fledglings/nest with eggs (e.g., Rusch and Doerr 1972, Rosenfield 1984, Crocoll and Parker 1989), and can vary among years (e.g., from 1.1 to 1.8 during 1976–1981; Rosenfield 1984). Variation probably related to differences in habitat and environmental conditions, but this needs study. Overall nest success (e.g., percent nests with eggs raising at least 1 young to fledging/year) varies from 50 to 100%; in w. New York, overall nest success varied between years, from 50 to 80% (Rusch and Doerr 1972, Rosenfield 1984, Crocoll and Parker 1989). Egg success in w. New York varies between clutch sizes: 80% of eggs hatch in 2-egg ($n = 10$) versus 87.5% in 3-egg ($n = 24$) clutches. Significantly more fledglings/egg produced from 2-egg clutches, 80% (100% of eggs hatched) versus 66.7% (76.2% of eggs hatched) in 3-egg clutches ($n = 24$) ($p < 0.01$; Crocoll and Parker 1989).

Most recorded mortality occurs during incubation and results from predation (Rosenfield 1984, Crocoll and Parker 1989). Loss of nestlings due either to predation (Rosenfield 1984, Crocoll and Parker 1989) or starvation (Crocoll and Parker 1989). In w. New York, loss of individual nestlings occurred only in clutches of 3 ($n = 8$) and 4 ($n = 2$); all nestlings fledged from 2-egg clutches (Crocoll and Parker 1989). Brood reduction only occurred in 3-nestling broods and represented 19% of young ($n = 21$; Crocoll and Parker 1989). Further study needed to identify causes.

In w. New York, mean fledglings/nest greater for new nests than for rebuilt nests (1.90 ± 1.00 SD [$n = 10$] vs. 1.20 ± 1.30 SD [$n = 5$]); greater for adult/adult pairs than for adult/second-year pairs (2.17 ± 1.17 SD [$n = 6$] vs. 1.50 ± 1.39 SD [$n = 4$]); more nests successful in deciduous-mixed woodlands (80%, $n = 11$) than in conifer plantations (57.1%, $n = 7$; Crocoll and Parker 1989). Also, 3-egg clutches produce more fledglings than 2-egg clutches (2.00 ± 1.06 SD [$n = 8$] vs. 1.60 ± 0.88 [$n = 5$]), but 2-egg clutches produce more fledglings/egg laid (0.80 [$n = 10$] vs. 0.67 [$n = 24$]) and more fledglings/egg hatched (1.00 [$n = 8$] vs. 0.76 [$n = 21$]) because brood reduction occurs in 3-nestling broods (Crocoll and Parker 1989).

LIFE SPAN AND SURVIVORSHIP

Not well studied. Based on band-recovery data from 1955 to 1979, average survival 12 mo ($n = 37$; Keran 1981). Band-recovery data may be biased toward weaker, more vulnerable birds as Broad-winged Hawks are rarely trapped; and winter recoveries may be more likely for young birds on U.S. range. Oldest recovered bird, 14 yr 4 mo, originally banded as an adult (Clapp et al. 1982). Estimate of longevity undoubtedly low due to low numbers banded (<4,000, with 172 recovered; Bird Banding Lab).

DISEASE AND BODY PARASITES

Little studied. Avian pox infection known from a captive bird (Schroder 1981). Larvae of the fly *Protocalliphora avium* found infesting ear cavities of 18- to 26-d-old nestlings; these larvae cause swelling, some bleeding, and scab formation, but are not known to cause mortality (Crocoll and Parker 1981). Two of 3 Broad-winged Hawks examined in a

Florida study were infected with blood parasites, i.e. *Haemoproteus elani* and *Plasmodium* (*Novyella*) sp. (Forrester et al. 1994).

CAUSES OF MORTALITY

In addition to predation (see Behavior: predation, above; also Conservation and Management: effects of human activity, below), causes of mortality include trapping (rare), shooting, and vehicle strikes (Burns 1911, Keran 1981, Loos and Kerlinger 1993, STC). High winds can destroy nests (Rosenfield 1984). Cannibalism and starvation of nestlings reported (Heintzelman 1966, Lyons and Mosher 1982, Crocoll and Parker 1989).

RANGE

***Natal philopatry*.** Few data. Only 2 returns from banded nestlings, one recovered approximately 320 km west of banding site 5 yr after hatching and the other recovered in nest area where banded 5 yr after banding (STC).

***Fidelity to breeding site and winter home range*.** No information on fidelity to winter home range. Little information on breeding-site fidelity. Of 2 pairs banded as adults in the Adirondack Mtns., NY, one pair remated and nested approximately 400 m from its previous year's nest (Matray 1974). In same study, 2 additional banded birds were retrapped on the same breeding area the following year ($n = 18$; Matray 1976). Given the number of used nests found in w. New York territories, Broad-winged Hawks probably reuse the same breeding area for several years (STC), but this needs further study.

***Home range*.** Little studied. A breeding male had a larger home range than his mate during the incubation and nestling period (Fuller 1979). In winter, birds are solitary and reportedly territorial; they appear to maintain a single hunting area of unknown size (Tabb 1973, Smith 1980).

POPULATION STATUS

***Numbers and trends*.** Migration counts in e. Mexico provide a minimum estimate of *B. p. platypterus* populations, with up to 1.7 million migrant Broad-winged Hawks recorded in 1 fall (Ruelas Inzunza pers. comm.). Survey methods for birds on breeding range appear inadequate. U.S. Fish and Wildlife Service's Breeding Bird Surveys (BBSs) detect low numbers per route. Call playback experiments suggest surveys using playbacks are of limited usefulness as well (Devaul 1990).

BREEDING. Nests throughout Northeast; common to abundant in New England and in Adirondack and Appalachian mountains, uncommon in more open agricultural areas (Titus et al. 1989). Analysis of BBS data by state suggests greatest densities in n. New York, Vermont, New Hampshire, and northward in spruce (*Picea*)-hardwood forests (Robbins et al. 1986, Titus et al. 1989). Breeding density in a Wisconsin study estimated at 1 pair/5.2 km^2 (Keran 1978); in Minnesota, 1 pair/2.4 km^2 (Rosenfield 1984); in w. New York, 1 pair/2 km^2 (Crocoll and Parker 1989); and in Alberta, at edge of range, 1 pair/23.3 km^2 (Rusch and Doerr 1972). Nearest-neighbor distances 1,441 ± 331 (SD) m, ($n = 12$) in w. New York (Crocoll and Parker 1989).

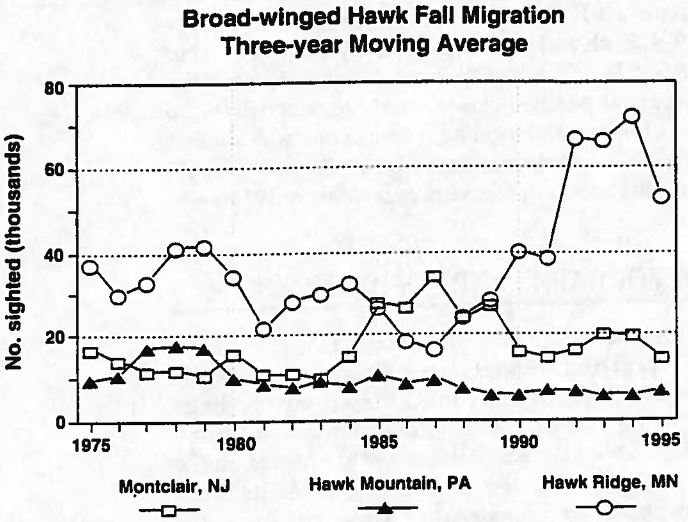

Figure 5. Fall migration counts of Broad-winged Hawks at 2 eastern flyways (Pennsylvania and New Jersey) and 1 central flyway (Minnesota). From M. Evans and E. Greenstone, pers. comm.

From 1966 through 1979, breeding Broad-winged Hawks detected on BBS routes increased in central U.S., New York, and Massachusetts. Listed as stable by most northeast wildlife agencies in 1989 survey (Titus et al. 1989). Further analyses of BBS data from 1966 through 1987 suggest that species has increased at 1.6%/yr in the less-developed regions of ne. U.S. and decreased at 1.1%/yr in more-developed regions of ne. U.S. (Titus et al. 1989).

In se. U.S., species is widespread in Appalachian Mtns., uncommon on coastal plain and in Piedmont regions. Small sample sizes for BBS routes in southern states impede accurate assessment of trends, although most states estimate stable populations as of 1989 (Mitchell and Millsap 1990).

MIGRATION. Migration counts at Hawk Mountain Sanctuary, PA, show a stable trend from 1936 to 1986 (Bednarz et al. 1990), but counts between 1990 and 1994 in Northeast suggest a possible decline in some eastern populations, or a change in migration routes with sightings declining at inland watch sites (see Fig. 5). In a multisite analysis of eastern migration-watch sites from 1972 to 1987, Titus and Fuller (1990) also detected a probable decline in Broad-winged Hawk numbers.

It is unclear if a drop in migration numbers represents a population trend or change in migration patterns in the eastern range. Although forested habitat appears to be increasing in the Northeast (Brooks 1989), the increase in forest maturity and level of fragmentation may influence quality of breeding habitat for this species (see Habitat: breeding range, above).

Migration-count sites in the central U.S. show stable numbers or increases from 1975 to 1994 (see Fig. 5).

Wintering. Rare in Florida and s. U.S. (see Distribution, above). Most band recoveries (45%) are from Central America (SES). Individuals remaining in Florida and other southern states during winter probably number only a few thousand. On 10 Christmas Bird Counts (CBCs) in 1982 in s. Florida, 59 Broad-winged Hawks were reported, with 27 on one count in the lower Keys (Sykes 1983).

Rare to uncommon over Middle America from s. Mexico (south of about 17°N) to Nicaragua, except for Yucatán Peninsula, from which species is essentially absent in winter.

More abundant from Costa Rica south through Panama, Colombia, and Venezuela (e.g., Hespenheide 1980). East of Venezuela, status uncertain; appears to be a rare winter resident in Guyana, Suriname, and French Guiana (e.g., Donahue 1985).

South of Colombia and Venezuela, wintering birds found regularly in low numbers west of the Andes as far south as Lima, Peru, and east of the Andes to sw. Matto Grosso in Brazil and Cochabamba and Santa Cruz in Bolivia (SES). Broad-winged Hawks found south of Colombia and Venezuela appear beyond the species' primary winter range.

Wintering birds appear rare in Caribbean, although status is uncertain and deserves attention (see Habitat: wintering range).

POPULATION REGULATION

Few data. Food supply may limit breeding density. Competition with other raptors for nest sites also may influence distribution and density. Nest predation can have a substantial impact on productivity in some areas (Crocoll 1984; see Behavior: predation, above). Shooting and habitat destruction limit populations in the West Indies (Wiley 1986).

Mortality on migration is probably higher than for many other raptors, given extent and duration of flight. Starved or emaciated immature birds are found consistently in Panama during migration (Smith 1985b). Some birds succumb during water crossings on migration (Kerlinger 1989).

Wintering birds appear to require large forests, and may set up solitary territories. Deforestation in Central and South America may limit habitat for wintering birds and migrants.

CONSERVATION AND MANAGEMENT

EFFECTS OF HUMAN ACTIVITY

Little studied. Early in twentieth century, shooting birds on migration and during breeding may have had a significant impact on this species (e.g., 1,500–2,000 killed in Minnesota in Apr 1925 during migration; Bent 1937). Burns (1911) reports that one man shot 298 in 1 d in New Jersey. More recently, habitat alteration, fragmentation, or elimination, particularly on wintering range, may pose a more serious threat.

Band-recovery data suggest that shooting on wintering range continues to affect this species, although proportion of banded Broad-winged Hawks recovered as shot in Latin America dropped from 100% in 1950s to 71% in 1970s (*n* = 38; Robbins 1986). In Mexico and south, migrants are still shot; people widely view raptors as pests, and protective laws are not enforced (Ramos 1986, Wiley 1986, Bildstein et al. 1993). Migrants are also trapped for use as pets and food (E. Ruelas Inzunza pers. comm.).

This species' reliance on amphibians for food may have allowed it to escape the drastic declines shown by other North American raptors due to DDT impacts in 1950s and 1960s (see Food Habits: diet, above). Recent increased use of DDT south of U.S. may affect some birds where winter diets may include more insects (Iñigo and Riseborough 1989). Pesticide impacts on this species remain undetermined, but impacts of recent forest insect pest control need further study. Regional pollution impacts on this species' amphibian prey also need study.

In Florida Keys, many wintering individuals hunting along highways are killed by vehicles (Tabb 1973).

Reforestation of ne. U.S. may have increased breeding habitat for this species in twentieth century (Brooks 1989). Overall forest area in northeastern breeding range appears to have increased by 33% from 1959 to 1982 (Goodrich and Bednarz 1989); proportion remaining in large tracts suitable for nesting is unknown. Fragmentation of forests through human development may create increasing stress on nesting birds; extent of impact is unclear. Nest disturbance could be a threat near lakefront areas in Canada (Armstrong and Euler 1983).

In contrast, forest area on the wintering range of *B. p. platypterus* may have decreased by >50,000 ha (4%) from 1972 to 1982 (Goodrich and Bednarz 1989).

Deforestation and unrestricted shooting have affected resident subspecies in the West Indies (Wiley 1986), although species is still reported as common in Cuba. Rare in Puerto Rico owing to clearing of virgin forests, which were almost entirely cut by 1912 (Wiley 1986). Puerto Rican subspecies declared endangered in fall 1994 by U.S. Fish and Wildlife Service; population estimate there in 1994 was 124 birds (M. Rivera pers. comm.). Decline in the West Indies sugar-cane industry may improve forest habitat on islands in the future (Wiley 1986).

MANAGEMENT

Few data. Should be considered in timber-management plans (Nelson and Titus 1988, Mitchell and Millsap 1990). Short timber rotations of <40 yr may be inadequate to maintain this species as a breeder in southern forests (Mitchell and Millsap 1990). Appears to select larger trees (>20 cm diameter at breast height [DBH]) for nesting (Titus and Mosher 1987). Small clearings and wetlands need to be maintained in vicinity of nesting areas (Keran 1978, Crocoll and Parker 1989). Breeding birds appear to use mostly large, continuous forest (see Habitat: breeding range, above), but species may be more tolerant of silviculture than other woodland raptors (Nelson and Titus 1988).

Habitat needs on migration and wintering areas also include woodland (e.g., Smith 1985a, Ruelas Inzunza et al. 1993). Preservation of forest patches for roosting along major flyways (e.g., in s. Texas and e. Mexico) may be vitally important for this and other long-distance migrants. Further research is needed on habitat use on migration and wintering areas, survivorship, and role of forest age and size in breeding success and population stability.

APPEARANCE

MOLTS AND PLUMAGES: LIGHT MORPH

Plumage colors primarily from Burns 1911 and Friedmann 1950; color numbers as described in Smithe 1975. The following descriptions are for *B. p. platypterus*.

Hatchlings. At hatching, covered with short, dirty white down (Weatherbee and Weatherbee 1961). Thick white prepennae down, basally grayish, emerges after several days (Burns 1911, Bent 1937, Lyons and Mosher 1987) (see Breeding: young birds, above).

Juvenal plumage. Primaries and secondaries emerge at 9–11 d followed by caudal, humeral, spinal, ventral, and capital feather tracts, respectively (Lyons 1983). Full Juvenal plumage observed in Jul after hatching (Bent 1937) and retained for 1 yr (through following spring; Burns 1911).

Sides of head similar to Definitive Basic (adult) plumage but paler. Head and nape dark brown, although considerable basal white shows. Indistinct pale superciliary line. Chin, throat, nape, and breast whitish, spotted with tear-shaped marks of dark brown.

Upperparts similar to adult, but feathers with buffy brown edges. Upperwing-coverts dull brown, edged tawny (38) or amber (36). Underparts white to buff (24) with dark-brown streaks on sides and flanks, fewer on abdomen. Undertail-coverts white. Underwing secondary-coverts whiter than in adult (Burns 1911, Wetmore 1965).

Tail longer and narrower than in adult. Rectrices buffy brown to olive brown (28), crossed by 5–6 indistinct narrow bars of dusky brown (19), and subterminally by a broad band of dark olive brown (21); tail tipped with white. Outer rectrices have very narrow dark barring on inner vane (Burns 1911, Friedmann 1950).

Upper wing dark brown, fading to white on outer primaries (Palmer 1988). Inner web barred brown, and tipped in gray. Under wing white stained with buff; deep brown spots occasional (Burns 1911). Wing similar to Basic I plumage (Palmer 1988).

Basic I plumage. Prebasic I molt is usually complete; secondaries occasionally retained (D. Brinker in Palmer 1988). In a female and male captive bird, this molt began in the Apr (female) and May (male) following hatch year and was completed by Aug and Sep, respectively (Burns 1911; see Fig. 4). Primaries and their coverts molted simultaneously, inner to outer; scapulars soon thereafter (Burns 1911, Palmer 1988). Secondary-coverts molted later than secondaries; feathers almost always lost in pairs from wings; sequence varies (Burns 1911). Central rectrices lost first, and upper-and undertail-coverts molted in concert with associated rectrice (Burns 1911).

Definitive Basic plumage. Acquired in summer and retained for 1 yr. Heaviest molt during Jun and Jul with sequence similar to Basic I, although beginning slightly later by 1 wk (Burns 1911, Palmer 1988). Molt usually completed by late Sep (Burns 1911, Palmer 1988). Sexes alike.

Dorsal plumage from forehead, mantle, and scapulars to rump sepia brown, hair brown (119A) to blackish brown, or dark gray-brown (21). Crown feathers edged in dull white. White feather bases and feather edged in whitish to mikado brown (121C) in occipital region and nape. Lores whitish to pale buff (124) with cheeks brown to fuscous (21). Cheek feathers with pale tawny or buff brown (38) edgings, appearing streaked. Black malar stripe. Chin and throat whitish to white, occasionally tinged buff (24; Friedman 1950).

Breast with dark barring varying from cinnamon brown to brownish red on whitish base color. Abdomen, sides, and flanks similar to breast but more clearly barred with white interspaces larger; brown markings smaller posteriorly. Lower abdomen white or lightly marked. Thighs similar to sides with brownish streaks (Friedmann 1950).

Uppertail-coverts dark brown to Vandyke brown (121), lightly tipped in white. Undertail-coverts pure white, sparsely marked with pale brown (Burns 1911, Friedmann 1950). Tail black, prominently crossed with whitish bands. Rectrices dull black with indistinct terminal band of dark drab (119B) fading to white. Middle of tail has a broad (15–20 mm) band of dull light umber (223), beige (219D), or dull white. Another slightly narrower band of same color crosses rectrices at or under the uppertail-coverts. Outer rectrices have a total of 3–4 blackish bars (Friedmann 1950, Burns 1911).

Outer webs of primaries barred fuscous (21) to brownish, inner webs typically white barred with 5–6 black bars; bars incomplete on outer feathers. Secondaries hair brown (119A), fading to white on inner webs. Barred with fuscous (21); terminal band narrowly tipped with light brown. Upper-coverts similar. Undersecondary-coverts white with some dull brown markings (Friedmann 1950, Palmer 1988).

MOLTS AND PLUMAGES: DARK MORPH

***Hatchlings*.** No information.

***Juvenal plumage*.** Head and underparts similar to dark morph adult but show rufous and white mottling on underparts, especially breast. Tail colors similar to those in Juvenal-plumage light morph (Friedmann 1950, Wheeler and Clark 1995).

***Basic I plumage*.** No information.

***Definitive Basic plumage*.** Plumage largely dark sooty brown. Feathers of head, neck, and dorsal surface sooty brown with sooty gray feather bases. Feathers of occipital region snow white on basal half. Forehead sooty black, anterior portion of lores grayish white with black streaks. (Friedmann 1950).

Underparts, including chin, throat, breast, abdomen, and underwing-coverts, solid dark sooty brown (Wheeler and Clark 1995).

Tail similar to adult light morph but light bands grayer. Uppertail-coverts with 2 pale gray bars on each feather. Tail black, tipped with narrow band of gray-black crossed at 36 mm from end by band of brownish gray fading to white on inner web edge, and approaching white on anterior portion of middle rectrices band (Friedmann 1950). A second band of dull gray crosses the tail 100 mm from tip; base of tail sooty gray (Friedmann 1950).

Wings lighter overall than back and underparts. Primaries uniform dusky brown on outer webs becoming gradually blackish terminally. Inner webs of 3 outer feathers chiefly white anterior to emargination, all others dull brown with dusky brown bands. Secondaries lighter brown than upper- and underwing-coverts, with no markings except near tip. Tip crossed with broad, dusky subterminal band and narrow pale edge. Undersurface of remiges grayish, indistinctly barred darker and with a broader dark subterminal band forming a dark bar along trailing edge of wing. In flight, from below, light gray remiges contrast with dark underwing-coverts (Wheeler and Clark 1995).

MOLTS AND PLUMAGES: OTHER SUBSPECIES

Appearance of adult *B. p. cubanensis* similar to nominate subspecies with dark streaks on breast rather than bars. Juvenal plumage same as for *B. p. platypterus* (Friedmann 1950). *B. p. brunnescens* is the darkest subspecies: blacker on mantle, with cheeks, throat, and neck with heavy black feather shaft streaking. Underparts tawny-olive (223D) barred with brown. Rectrix barring duskier and washed with smoke gray (44). Immature similar to nominate subspecies but streaks darker, fuscous (21) to dark brown (Friedmann 1950). *B. p. insulicola* is paler than all other subspecies: forehead, lores, and occipital area whitish. Crown and ear-coverts gray brown, rictal streak darker with feather tipped with sooty brown. Mantle blackish brown, upper back barred with white. Underparts similar to nominate subspecies. *B. p. antillarum* has chin and throat more abundantly streaked than *B. p. platypterus*. Juvenal plumage shows more tawny buff on underwing-coverts than nominate subspecies. *B. p. rivierei* is similar to *B. p. antillarum* but darker overall with crown fuscous black and breast markings tawnier (Friedmann 1950).

MOLTS AND PLUMAGES: ABERRANT PLUMAGES

In addition to rare dark (melanistic) individuals, a few albinistic individuals are reported (Palmer 1988); 1 partial albino observed nesting in e. Pennsylvania for 2 consecutive years (F. Wetzel pers. comm.), and 1 probable complete albino observed on migration in e. Mexico (LJG). Some North American adults with more rufous (240) overall than others (Friedmann 1950).

BARE PARTS

***Hatchlings*.** Beak nearly black, cere pale yellow, edge of gape flesh color, eyes blue-black (90) or blue-gray, talons gray (Burns 1911, J. Mosher *in* Palmer 1988).

***Juvenal plumage*.** Iris gray or pale light brown, turning brown late in year (Burns 1911). Cere, legs, and feet pale yellow, talons black (Friedmann 1950, Palmer 1988).

***Definitive Basic plumage*.** Beak black grading to gray-blue. Cere pale yellow to chrome yellow. In light morph bird, iris from cinnamon (123A) or amber (36) to buffy brown. Iris red in dark morph birds. Legs and feet light yellow, talons blue-black (90) in both morphs (Burns 1911, Friedmann 1950).

MEASUREMENTS

Residents from Caribbean regions may be slightly smaller than mainland birds; more data needed (Friedmann 1950, Blake 1977; see Appendix 3). In Wisconsin, only 3% overlap reported in weights of males and females; males usually <385 g, most females >385 g (D. Brinker and T. Erdman *in* Palmer 1988). In New York between Apr and Jul, mean weight of 10 males: 357 ± 24.6 (SD) g; of 11 females: 437 ± 23.8 (SD) g (Mosher and Matray 1974).

Females have longer wings than males, but ranges overlap (D. Brinker and T. Erdman *in* Palmer 1988): mean male wing 269 ± 4.9 (SD) mm ($n = 10$), mean female wing 285 ± 5.6 (SD) mm ($n = 11$) (Mosher and Matray 1974). Flattened wing length can provide predictive accuracy for nestling age within sexes, up to 35 d of age (Lyons and Mosher 1983). Flattened wing length measured on museum specimens of full-grown, juvenile Broad-winged Hawks showed females with a mean of 278 mm (260–295, $n = 24$), males with a mean of 269 mm (243–287, $n = 24$) (Lyons and Mosher 1983).

Hatching-year (HY) birds measured on migration at Hawk Ridge Observatory, Duluth, MN, have longer tails, lower mass, and similar wing chords compared with after-hatching year (AHY) birds. Tail: AHY mean 157.1 ± 7.6 (SD) mm, HY mean 165.7 ± 6.7 (SD) mm; weight: AHY mean 413.5 ± 53.7 (SD) g, HY mean 373.9 ± 50.1 (SD) g; wing: AHY mean 273.8 ± 10.5 (SD) mm, HY mean 273.4± 10.0 (SD) mm (n = 11 AHY, 252 HY; D. Evans pers. comm.).

Two dark morph HY birds measured on fall migration at Hawk Ridge Observatory had wing chords of 265 and 291 mm, flattened wing length of 271 and 301 mm, tail lengths of 156 and 182 mm, and weight of 341.0 and 398.0 g, respectively (D. Evans unpubl. data).

OTHER

Three individuals from different geographic regions and dates reported with supernumerary toe on posterior side of tarsus. In all cases the toe arose from the muscle, and in 2 cases it appeared similar to other toes in form and coloration (Beebe 1910).

PRIORITIES FOR FUTURE RESEARCH

Of greatest priority is research on population ecology of Caribbean subspecies, especially defining distributions, habitat needs, and genetic distinction from continental subspecies. For all resident subspecies, basic data are needed on body measurements, adult and nestling behaviors, diet, and vocalizations.

On the continental breeding range, research is needed on home-range size, minimum forest size for stable populations, lifetime reproductive output, long-term survivorship, and rates of return to breeding and wintering sites. Long-term studies of marked pairs are especially needed. More nesting studies are needed at range limits, particularly in the western part of the range. Re-surveying prior study areas could clarify variability in nesting densities. Little is known of the distribution and incidence of dark-morph birds.

Additional research is needed to design and validate population survey methods for this and other woodland raptors (Titus et al. 1989), particularly in light of suggested declines.

For migrants, information is needed on fat deposition, feeding, and roosting habitat. Projects using radio or satellite telemetry would better define migration dynamics, routes, and roosting sites.

Winter distribution, behavior, and ecology remain poorly known. Information on age and sex segregation on wintering grounds, winter habitat requirements, food habits, and overwinter survivorship would assist long-term conservation efforts for this neotropical migrant.

ACKNOWLEDGMENTS

We are grateful to A. Poole for many helpful contributions, to K. L. Bildstein, M. Fuller, P. Kerlinger, S. Russell, and K. Titus for comments on earlier versions of the manuscript, and to J. Brett for early encouragement. D. Lasher typed part of the manuscript. W. Loder assisted with references. L. Kiff and staff of the Western Foundation of Vertebrate Zoology provided egg measurements, and S. L. L. Gaunt and staff of the Borror Laboratory of Bioacoustics at Ohio State University contributed sound spectrograms. C. R. Chandler contributed the section on Fossil History.

Analysis of wintering locations, band recoveries, and museum specimens by SES was supported by the U.S. Fish and Wildlife Service's Office of International Affairs. K. Brink assisted with literature on migration and wintering ranges. Band recovery data were provided by the Bird Banding Laboratory. We particularly thank the banders who contributed these data and the BBL staff. Breeding Bird Survey data were provided by S. Droege and the National Biological Survey. Migration data were provided by E. Greenstone and W. Greenstone of the New Jersey Audubon Society, the Hawk Mountain Sanctuary Association, and M. Evans of the Hawk Ridge

Observatory, Duluth Audubon Society, MN. D. Evans and Hawk Ridge Observatory provided unpublished measurement data. This account is Hawk Mountain Sanctuary Contribution no. 26. Cover photo © B. K. Wheeler/VIREO.

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Appendix 1. Percentage of prey by type brought to Broad-winged Hawk nests. Data collected using direct observations or prey remains.

State	Nests	Mammals	Birds	Reptiles	Amphibians	Invertebrates	Source
New York	4	46.1	21.0	5.7	27.9	-	Mosher and Matray 1974
New York	13	46.4	26.1	13.0	13.0	trace	Crocoll and Parker 1989
Maryland	-	52.0	10.0	6.0	-	32.0	Janik and Mosher 1982
Wisconsin	1	40.2	28.0	7.5	24.2	-	Rosenfield et al. 1984
Alberta	2	62.0	27.0	-	9.0	2.0	Rusch and Doerr 1972
Eastern U.S.	-	12.2	8.2	24.5[1]	-	55.1	Burns 1911
Kansas	3	26.1	25.4	37.0[1]	-	8.7	Fitch 1974

[1] Percentage includes both reptiles and amphibians.

Appendix 2. Nest site parameters of different Broad-winged Hawk populations. Data shown as mean ± SD (*n*).

Location (Source)	Nest Height (m)	Diameter at Breast Height^2 (cm)	Distance to Wet Area (m)	Distance to Opening (m)
Adirondack Mts., NY (Matray 1974)	13.3 ± 1.36 (14)	54.1 ± 8.3 (14)		
Central Ontario (Armstrong and Euler 1983)	11.8 ± 2.8 (27)	44.2 ± 16.2 (27)	51.5 ± 30.8 (27)	42.1 ± 30.2 (27)
Wisconsin (Rosenfield 1984)	8.2 ± 2.7 (72)	31.5 ± 6.3 (72)		
Wisconsin (Titus and Mosher 1987)	10.4 ± 2.6 (34)	34 ± 8 (34)		
North-central Minnesota and Wisconsin (Keran 1978)	9 (29)	25 (29)	143 (29)	124 (29)
Western New York (Crocoll and Parker 1989)	11.8 ± 3.2 (18)			90 ± 54 (17)
Western Maryland (Titus and Mosher 1981, 1987)	14.8 ± 3.2 (112)	44 ± 14 (112)	86 ± 60 (24)	63 ± 61 (24)
Pennsylvania (Grimm and Yahner 1986)	14.2 (50)	29.5 (50)	128 (50)	140 (50)
Texas (Bush and Gehlbach 1978)	9 (1)	41 (1)	380 (1)	20 (1)

Appendix 3. Linear measurements (mm) of adult Broad-winged Hawks by subspecies. Data shown as mean (range).

Subspecies (range)	*B. p. platypterus*[1] (U.S./Canada)	*B. p. cubanensis*[1] (Cuba)	*B. p. brunnescen*[1] (Puerto Rico)	*B. p. insulicola*[1] (Antigua)	*B. p. rivierei*[1] (Dominica)	*B. p. antillarum*[3] (Trinidad, Tobago, Lesser Antilles)
Sample size (male/female)	17/17	2/3	1/1	1/–	1/1	4/3
Tail						
Male	159 (148–173.5)	160 (150–156.6)	151	145.9	149	154.9 (148.1–163.5)
Female	171 (155–185)	161 (160.1–164)	159		145	158.9 (153.6–166.6)
Wing						
Male	263 (244–277)	(250–256)	257	227.0	245	260.4 (254.5–268)
Female	283 (265–296)	261 (254–266)	264		250	267.4 (260.8–272.6)
Tarsus						
Male	62 (57.5–65.5)	65	59.5	56.0	55.5	55.1 (53.2–57.9)
Female	63 (59–66.4)	61 (59.5–61.5)	56.3		54.4	55.4 (54–57)
Culmen						
Male	18 (17–20)	18.6 (17.5–19.7)	18.5	18.5	19.3	18.8 (18.4–19.8)
Female	19 (17.1–20.5)	20.2 (19.5–21.3)	20.8		18.0	19.9 (19.3–20.5)
Toe						
Male	33 (30.8–36.6)	35.5 (33.5–37.5)		29.2	29.5	
Female	34 (31.7–36.5)	31.5 (30.2–32.5)			29.0	

[1] Friedmann 1950.
[2] Burns 1911.
[3] Blake 1977.

Appendix 4. Distribution of 191 museum specimens collected during the nonbreeding season (Dec–Feb). Specimens examined were from the following museums: Am. Mus. Nat. History, Acad. Nat. Sci. Phila., Carnegie Mus. Nat. Hist., Field Mus. Nat. Hist., Mus. Comparative Zool., Mus. Vertebrate Zool., Natl. Mus. Nat. Hist., Del. Mus. Nat. Hist., Louisa. State Univ. Mus. Zool., Univ. Michigan Mus. Zool., Calif. Acad. Sci., West. Found. Vertebr. Zool., Fla. State Mus., and Univ. Kansas Mus. Nat. Hist. Data shown as number specimens (column %).

Location	Male	Female	Unknown Sex	Adult	Immature	Unknown Age	Total Specimens
Florida	4 (4.5)	7 (7.6)	2 (18.2)	2 (2.2)	11 (11.2)	0	13
Mexico	10 (11.4)	14 (15.2)	2 (182)	11 (12.1)	15 (15.3)	0	26
Central America[1]	19 (21.6)	24 (26.1)	1 (9.1)	23 (25.3)	19 (19.4)	2 (100)	44
South America[2]	55 (62.5)	47 (51.1)	6 (54.5)	55 (60.4)	53 (54.1)	0	108
Total	88	92	11	91	98	2	191

[1] Central America = Guatemala, El Salvador, Nicaragua, Costa Rica, and Panama.
[2] South America = Colombia, Venezuela, Brazil, Surinam, Ecuador, Peru, and Boliva.

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The Birds of North America accounts (ISSN 1061–5466) are published bimonthly by The American Ornithologists' Union and The Academy of Natural Sciences, Benjamin Franklin Parkway, Philadelphia, PA 19103–1195. Printed by Smith-Edwards-Dunlap Company, Philadelphia, PA.

The Birds of North America is supported by charitable and governmental organizations including: The Office of Migratory Bird Management (USFWS), National Fish and Wildlife Foundation, The McLean Contributionship, The Geraldine R. Dodge Foundation, The Richardson Foundation, and the American Birding Association. Benefactors of this program include Wallace C. Dayton and Joseph and Helen Taylor.

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RECOMMENDED CITATION
Goodrich, L. J., S. C. Crocoll, and S. E. Senner. 1996. Broad-winged Hawk (*Buteo platypterus*). *In* The Birds of North America, No. 218 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, D.C.

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