Patterns in Movement, Captures, and Phenology of Sharp-shinned Hawks in Central Coastal California

Author(s): Susan Culliney and Thomas Gardali
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ABSTRACT.—Between 1979 and 2006, we captured 452 Sharp-shinned Hawks (Accipiter striatus) at the Palomarin Field Station in the Point Reyes National Seashore, Marin County, central coastal California. Of all captures, the majority, 83%, were young males. We recaptured 46 individuals; 42 were originally banded at our site, and four were originally banded at a site 24 km southeast of our banding site, suggesting that our site may be a point on migration or a wintering destination for some Sharp-shinned Hawks. We captured Sharp-shinned Hawks during every month of the year, with peak captures occurring in the fall from late September to mid-November. Capture rate significantly increased over the course of our study, consistent with results from some other monitoring programs.

KEY WORDS: Sharp-shinned Hawk; Accipiter striatus; California; capture trend; migration; mist nets; monitoring.

Researchers at hawkwatch count sites and hawk-banding stations frequently monitor Sharp-shinned Hawks (Accipiter striatus) during migration when they are visible and concentrated in high numbers for counts and capture and marking studies. Data collected during migration using these methods was critical in the past for charting the status of Sharp-shinned Hawk populations. Eastern migration hawkwatch stations observed declines in Sharp-shinned Hawk counts until the 1970s when DDT was banned in the United States (Bednarz et al. 1990, Bildstein and Meyer 2000) and the species was subsequently placed on several state special concern lists, including in California (Remsen 1978, Bildstein and Meyer 2000).

Researchers have also studied Sharp-shinned Hawks beyond the conspicuous migration by using counts in breeding habitat (Sauer et al. 2007) and counts and telemetry on wintering grounds (Duncan 1996, Sutton and Kerlinger 1997, National Audubon Society 2002, Roth et al. 2005). Although obtaining data from outside the migration season is more challenging, these data play an important role in Sharp-shinned Hawk conservation by providing evidence about breeding and wintering habitat, and this information can be used to inform land-conservation priorities (Sutton and Kerlinger 1997).

Another potential source of data on Sharp-shinned Hawks during all seasons of the year may be passerine mist-net stations, which occasionally catch the small accipiter in their passive nets. We offer an example of how this type of data can contribute to knowledge about Sharp-shinned Hawks. Based on 27 yr of year-round mist-net captures, we document age and sex classes, recaptures, seasonal
phenology, and changes in annual capture rates of Sharp-shinned Hawks at Palomarin, a constant-effort mist-netting site in central coastal California.

Methods

Between 1979 and 2006, as part of a long-term avian monitoring program, banders captured, measured, and banded Sharp-shinned Hawks at the Palomarin Field Station, located within the Point Reyes National Seashore, Marin County, California (37° 56′ N, 122° 45′ W). Although hawk captures are not the primary purpose of the monitoring program, we were able to conduct a post-hoc analysis of Sharp-shinned Hawk captures. Banders assigned sex to Sharp-shinned Hawks based on wing-chord measurements, and assigned age based on plumage and eye coloration differences between young and adult birds according to criteria in Mueller et al. (1979) and Bildstein and Meyer (2000).

The study area is primarily coastal scrub (dominated by Baccharis pilularis and Artemisia californica) and coast live oak (Quercus agrifolia) riparian forest. During the 27 yr of the study, changes in habitat structure and plant species composition occurred in the study area. These changes were not quantitatively assessed, but they include encroachment of Douglas-fir (Pseudotsuga menziesii), reduction of herbaceous cover, and increases in height of trees. For further description of the site see DeSante and Geupel (1987). Birds were caught in an array of twenty 12-m mist nets, fourteen of which (30-mm mesh) were set along the edge of riparian woodland in a mixed evergreen forest, with the remaining six (36-mm mesh) located in adjacent coastal chaparral.

Nets were opened 15 min after local sunrise and left open for 6 hr (weather permitting). During 1979–88 nets were run 3 d/wk December–March, 7 d/wk April–November; during 1989–2006, nets were run 3 d/wk December–April, 6 d/wk May–November.

We expressed capture rates as Sharp-shinned Hawks captured per 1000 net-hr (total number of captures divided by net-hr and multiplied by 1000). To convey seasonal phenology of captures, we plotted total seasonal capture rate for 1979–2006 by 10-d period to report descriptive statistics but did not subdivide seasons due to the already small sample size.

To describe recaptures, we classified hawks captured fewer than 30 d after a previous capture as “repeats” and hawks captured ≥270 d (approximately 9 mo) after a previous capture as “returns.” Hawks recaptured between 31 and 269 d may have represented birds remaining near Palomarin through the winter, or birds returning to Palomarin after traveling elsewhere; to be conservative, we did not classify these hawks as either repeats or returns. We defined the seasons by 3-mo periods: summer (June, July, August), fall (September, October, November), winter (December, January, February), and spring (March, April, May).

To evaluate capture-rate trends, capture totals were log-transformed in order to improve the normality of the residuals (Zar 1996). We then examined trends in capture rates using linear regression of the log-transformed annual capture rate in the STATA statistical analysis program (Stata Corp. 2003). We examined whether residuals from linear regression analyses demonstrated autocorrelation, using two procedures, the Cochrane-Orcutt and Hil-dreth-Lu methods (corc and hild) available in STATA (Cochrane and Orcutt 1949). We found no evidence for autocorrelation (all P > 0.1) of our capture data. We examined whether the trend was nonlinear by testing for a significant quadratic coefficient for year in the presence of a linear term; we found no significant quadratic coefficient for year. We assumed significance at P ≤ 0.05.

Results

Age and Sex of Captured Birds. We captured 452 Sharp-shinned Hawks from 1979–2006. Of these, 88% were young, 7% were adults, 92% male, and 7% female. Young males made up 83% of captures, adult males 6%, young females 6%, adult females less than 1%, and birds of unknown age and sex accounted for less than 5% (Fig. 1).

Recaptures. Of the 386 individual Sharp-shinned Hawks banded at Palomarin between 1979–2006, 42 individuals were later recaptured at Palomarin one or more times, for a total of 56 recapture events (excluding same-day-recaptures). Of the 56 recapture events, 19 were repeats and 10 were returns. The remainder of 27 recapture events did not fit into either category. Of the 46 individual recaptured hawks, 13 were recaptured <10 d later; the rest were recaptured from 10 to 953 d after their initial banding (Fig. 2). The mean number of days between captures was 137 (median = 70 d). Recaptured individuals were all male except for a single adult female and one hawk of unknown sex. Thirty-nine of the recaptured hawks were aged as young at banding, six were aged as adults, and one hawk was of unknown age.

Notable recaptures included three hawks each captured during the fall and again in the fall one
or two years later, a hawk captured in consecutive winters as well as in the spring between, a hawk captured in the spring and again in the spring nearly 2 yr later, and a hawk captured in late summer, then again in the spring 2 yr and 7 mo later. Another notable recaptured hawk was captured first in November, then twice in December of the same year, and twice again in the following April.

In addition to the 42 recaptured hawks originally banded at Palomarin, 4 recaptures were of birds originally banded in the months of August, September and October at the Golden Gate Raptor Observatory, located 24 kilometers southeast of our banding site at Palomarin. Two of these were recaptured in nets at Palomarin 20–31 d later, one was recaptured in December, and one was recaptured the following March (Fig. 2).

Seasonal Phenology. The total capture rate of Sharp-shinned Hawk from 1979–2006 for ten-day periods increased in mid-September to a high in late October, then dropped again through December to the early spring. Capture rate fell even further in early April and remained at this low level through the summer months (Fig. 1).

Trend in Capture Rate. Numbers captured per year ranged from 5–31 (2.8–11.8 per 1000 net-hr). Captures of Sharp-shinned Hawks increased significantly over the 27 yr of the study (slope = 0.032, 95% CI = 0.017–0.046, adj. $R^2 = 0.41$, $P < 0.001$; Fig. 3).

Discussion

Age and Sex of Captured Birds. Each hawk-monitoring method has accompanying bias. Count data of Sharp-shinned Hawks may embody some observer error in sex, age, and accipiter species (Hull et al. 2010). Data from trapping stations may not precisely represent the sample population, as adult Sharp-shinned Hawks may be more difficult to trap (Mueller et al. 2000) and larger, more confident females could be more attracted to active luring (A. Hull pers. comm.). Capture data from passive passerine mist-nets may also induce bias, as mesh-size is a factor in capturing birds of different sizes (Jenni et al. 1996) and our smaller mesh-size likely favors the capture of smaller male hawks. Although each method contains some bias, some comparison is possible.
Raptor monitoring stations observe that Sharp-shinned Hawks are separated temporally by age and sex classes during both fall and spring migration (Mueller and Berger 1967, Rosenfield and Evans 1980, Hall et al. 1992, DeLong and Hoffman 1999, Mueller et al. 2003). Some stations also report a disproportionate overall rate of female captures (Carpenter et al. 1990) or counts of immature hawks (Hall et al. 1992, Niles et al. 1996). These data could indicate a possible spatial separation of the classes during migration, perhaps explained by differing experience and strength and therefore migratory routes and timing (DeLong and Hoffman 1999). Ralph (1978, 1981) showed that many young passerines follow the coasts for their first migration. The majority (90%) of Sharp-shinned Hawk cap-

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Figure 2. Representation of capture timing by 10-day period of Sharp-shinned Hawks recaptured ≥10 d after banding, 1980–2006. Dashed lines indicate that the location of hawks between captures is unknown. Triangles depict hawks originally banded at the Golden Gate Raptor Observatory; circles depict hawks banded and/or captured at Palomarin. All hawks were young males at banding unless otherwise noted.

Figure 3. Trend in capture rate of Sharp-shinned Hawks at the Palomarin Field Station, Marin County, California 1979–2006. Each circle represents data for one year; regression line is linear best fit ($R^2 = 0.41, P < 0.001$).
tures at the Golden Gate Raptor Observatory are young (A. Hull pers. comm.), which may be further evidence of this coastal effect, although active luring may favor young hawks, which are unskilled at migration and hunting. The majority (88%) of Sharp-shinned Hawks captured in the passive mist-nets at Palomarin were also young, which we believe should represent no age bias. Passive mist-nets are designed to be invisible to birds, and while it is possible that older Sharp-shinned Hawks may be more wary of other birds already captured in a net, we doubt that this alone would result in such a strong age bias. Some hawk captures result from chasing prey into a net rather than from taking already captured prey. The passive mist-netting method can instead be biased in regard to bird size (Jenni et al. 1996), but as young and adult Sharp-shinned Hawks of the same sex are nearly equivalent in size (Mueller et al. 1979), there is likely no inherent difference in capture probability between the age groups. Niles et al. (1996) suggest that young hawks are found disproportionately along the coasts, in part because of the abundance of easy prey in the form of the young passerines. Therefore, the high percentage of young hawks captured at Palomarin likely represents an actual age discrepancy in the area.

Although the proportion of young hawks captured at Palomarin should not be affected by our methods, the abundance of male hawks captured may be a bias induced by our capture methods. The mist-net mesh sizes used at Palomarin are intended to capture passerines safely, but may allow larger birds to escape. Hence, smaller male Sharp-shinned Hawks are more likely to be captured in these net sizes than larger females. This male bias at Palomarin is not reflected at the Golden Gate Raptor Observatory and may represent several behaviors. Some hawks recaptured as repeats during the fall or spring, or those captured in fall and again the following spring could simply be migrating through the area, having stopped briefly to rest or refuel in the forests at Palomarin. Those first caught in the late summer or fall and subsequently recaptured during that winter may have ceased migration to use the habitat as part of their wintering range. Those individuals recaptured several seasons or years later likely left the vicinity of Palomarin and then returned, suggesting that Palomarin may be a habitual migratory route or destination for some Sharp-shinned Hawks. One hawk, captured once in the fall, twice in the winter, and twice in the following spring, demonstrates more clearly that some hawks appear to winter around Palomarin.

Four captures of birds originally banded roughly 24 km southeast of Palomarin at the Golden Gate Raptor Observatory in the months of August, September, and October, also provide evidence that Palomarin is an area used by some Sharp-shinned Hawks during migration and winter. Two of the four were recaptured during the same fall in which they were banded. Although these hawks were moving north, they may have been continuing their migratory behavior, perhaps circuitously responding to the San Francisco Bay area’s topography by avoiding the water crossing (Mueller and Berger 1967, Kerlinger 1985, Hall et al. 1992) or navigating the peninsula (Mueller and Berger 1967, Sutton and Kerlinger 1997), as has been observed at other raptor monitoring stations in North America. Another of these birds was recaptured in our nets later in December and may have ceased migration to winter near Palomarin. The last of these birds was recaptured at Palomarin the spring following initial capture at Golden Gate Raptor Observatory and may have either been on a return migration or perhaps spent the winter in the area. These captures suggest that Palomarin is a point on a migratory route and/or a destination for some wintering Sharp-shinned Hawks. One possible reason that these hawks find Palomarin attractive for brief stops during migration or for longer stays over winter is the songbird prey base. Palomarin is on the southern end of Point Reyes, a site well-known for its songbird abundance and diversity.

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Seasonal Phenology. The objective of the mist-netting program at Palomarin is to passively trap landbirds throughout the year at a site where riparian forest and Douglas fir meet coastal scrub. The nearest raptor monitoring station is the Golden Gate Raptor Observatory, 24 km southeast of Palomarin, where researchers operate only during the fall to actively trap and band raptors on exposed hilltops in a coastal scrub–dominated landscape. Although the site types, capture methods, and seasonal effort differ between the two stations, the majority of captures of Sharp-shinned Hawks at Palomarin also occur during the fall migration season, making limited comparisons possible. Most captures at Palomarin are of male Sharp-shinned Hawks and occur between late September and mid-November. This corresponds broadly with the timing documented at the Golden Gate Raptor Observatory, where the majority of male Sharp-shinned Hawks are captured between 15 September and 27 November, with a possible peak in late September or early October (A. Hull pers. comm.).

The rough correspondence between Sharp-shinned Hawk captures at Palomarin and the Golden Gate Raptor Observatory during the fall demonstrates that songbird mist-netting programs can supplement the data collected by raptor trapping stations on Sharp-shinned Hawk abundance during fall migration. Additionally, year-round mist-netting stations may in some cases represent one of few data sources for Sharp-shinned Hawk presence, movements, and habitat choices outside of the migration seasons. The low number of spring and summer captures at Palomarin suggests little Sharp-shinned Hawk activity in the area and confirms this species’ status as an uncommon breeder in Marin County (Shuford 1993).

Trend in Capture Rate. The capture rate of Sharp-shinned Hawks increased significantly at Palomarin between 1979 and 2006. This capture rate may indicate a general trend for an increasing population of Sharp-shinned Hawks. In general, since the banning of DDT use within the United States, eastern populations of Sharp-shinned Hawks rebounded (Bednarz et al. 1990). Although lack of baseline data prohibits the definitive conclusion that western Sharp-shinned Hawk populations declined with the advent of DDT as was the case in the east, their eggs did contain high levels of DDE, the breakdown product associated with eggshell-thinning (Snyder et al. 1973), and a similar population rebound likely also occurred in the west following the banning of DDT. This supposition is supported by Christmas Bird Count data from 1959–88 in California, demonstrating a significant increase in numbers of Sharp-shinned Hawks counted (Sauer et al. 1996). Trends in the 1990s were less conclusive. Observers at northeastern hawkwatch sites recorded variable regional trends with an overall decline in counts of Sharp-shinned Hawks (Farmer et al. 2008a). Western population trends were similarly uncertain. Hoffman and Smith (2003) found that Sharp-shinned Hawks increased at one site in Nevada, in the Goshute Mountain Range within the Intermountain Flyway. Farmer et al. (2008b) pointed to decreasing or inconclusive trends in the west and attributed these fluctuating patterns to changes in Sharp-shinned Hawk migration routes, as hawks avoided drought in the west or exhibited migratory short-stopping. Increases at Palomarin may reflect this migratory short-stopping behavior, as Sharp-shinned Hawks take advantage of passerine prey attracted to bird feeders, as Viverette et al. (1996) suggested. Using mist-net data from passerine banding stations may be a way to further investigate these conflicting patterns.

If western populations of Sharp-shinned Hawks are indeed increasing overall, this could indicate that forest management practices currently favor the dense forests that this species uses for breeding. Our increasing capture rate may also reflect local habitat change at Palomarin. There has been an increase in height and cover of Douglas fir (Ballard et al. 2003), which may attract more Sharp-shinned Hawks (i.e., habitat has gone from primarily open scrub to a more forested environment) and hence influence local capture rates, regardless of overall western population numbers. It is also possible that a local increase in the amount of prey could result in an increase in captures of Sharp-shinned Hawks. At Palomarin, however, we have documented strong declines for the majority of passerines and near-passerines (Ballard et al. 2003).

It is also possible that our capture rates are providing an index of activity instead of abundance (Remsen and Good 1996). In other words, increased activities such as hunting in the vicinity of the net array could increase the capture probability regardless of the abundance of Sharp-shinned Hawks. One mechanism that could explain an increase in activity at Palomarin could be that Sharp-shinned Hawks need to work harder (i.e., increase the amount of activity) to capture prey, due to reported declines of passerines and near-passerines at Palomarin (Ballard et al. 2003). However, we would expect that an increase in activity would also result in an increase in
the number of within-season recaptures, which is not apparent in our data. Migratory hawks have been considered useful bio-indicators for charting ecosystem health (Bildstein 2001), and Sharp-shinned Hawks, as migratory raptors, can satisfy this role. We suggest that a potential way to augment Sharp-shinned Hawk monitoring during and beyond the traditional migratory period is to use data from long-term year-round passerine mist-netting stations. These capture data may uncover differential patterns in migration and wintering behavior, help clarify the possibly shifting migratory routes suggested by the conflicting trends across the west, and describe how and when these hawks use the habitat around passerine mist-net stations at all times of year. This information could improve our understanding of population trends and habitat preferences, and subsequently enhance management and conservation for this species.

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