Effects of backpack radiotags on female northern pintails wintering in California

Joseph P. Fleskes

Abstract To test whether backpack radiotags impacted the wintering biology of northern pintails (*Anas acuta*), I attached spear-suture (SSU, $n=82$ in 1993) or harness (HAR, $n=337$ in 1991–1993) backpack radiotags to female Hatch-Year (HY) and After-Hatch-Year (AHY) pintails after their autumn arrival in California. I evaluated impacts of radiotags on 1) wintering population distribution; 2) flock status, flock size, and body mass at harvest; and 3) August–March survival. I also compared retention of SSU and HAR following attachment. Distribution, flock status, and flock size at harvest of HAR, SSU, and unmarked (UMK) pintails were similar. However, harvest mass of HAR pintails averaged 133 g (SE=25 g) less than UMK pintails; loss tended to be greatest for heavier HY females in 1993. Daily survival rates during 1993–1994 of HAR vs. SSU pintails were similar for both HY (0.9979 vs. 0.9974) and AHY (0.9988 vs. 0.9986) female pintails. Retention ranged from 30–158 days ($\bar{x}=81$ d, SE=5 d) for the 37 SSU that I confirmed as being shed; all other SSU failed <158 days or were on pintails that died <158 days. Two HAR were shed during the 202–205-day annual study over 3 years. Both backpack radiotag types are appropriate for study of some aspects of pintail wintering ecology, but I recommend against SSU radiotags for >1-month studies due to poor retention past a month.

Key words *Anas acuta*, backpack, harness, northern pintail, radiotelemetry, spear-suture, transmitter

Radiotelemetry has been used extensively to study wildlife ecology. Several radiotag attachment methods have been developed for waterfowl in efforts to maximize information gained while minimizing impacts to those aspects of the bird's ecology that are of interest. Mallards (*Anas platyrhynchos*) with harness (HAR) backpack radiotags (Dwyer 1972) preened more and swam less (Greenwood and Sargeant 1973, Pietz et al. 1993) for a few days after tagging (Gilmer et al. 1974) than those without radiotags. These and other behavioral changes, even if temporary, may explain observed reduced productivity of female mallards equipped with HAR radiotags (Pietz et al. 1993, Rotella et al. 1993). Pietz et al. (1995) recommended use of spear-suture (SSU) backpacks for studies of mallard breeding ecology to avoid potential behavioral problems caused by HAR backpacks and increase retention above that of backpack radiotags attached with sutures alone, which were poorly retained (Rotella et al. 1993). However, Paquette et al. (1997) reported that breeding female mallards with SSU radiotags had lower productivity and survival than females with radiotags surgically implanted into the abdominal cavity and recommended using implanted radiotags for studies of waterfowl productivity.

Because radiotag performance and impacts to bird ecology vary among radiotag types, the most appropriate design depends upon the ecology of the species during the study period. Although backpack radiotags might be inappropriate for

Author's address: United States Geological Survey, Western Ecological Research Center, 6924 Tremont Road, Dixon, CA 95620, USA; e-mail: joe_fleskes@usgs.gov.

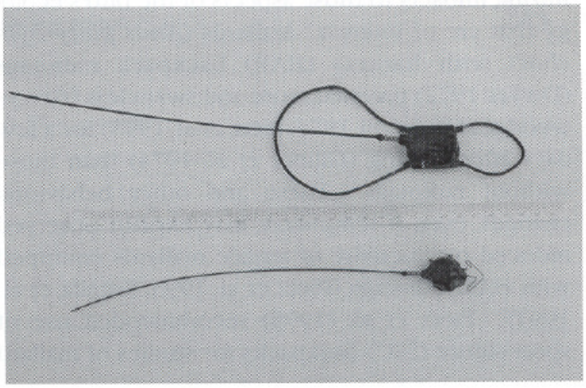
study of waterfowl productivity, they may be a useful tool for study of some aspects of ecology during the nonbreeding season. In addition to being easier to attach than internally implanted radiotags, backpacks have greater reception range, which aids in locating individuals (Paquette et al. 1997). Thus, HAR or SSU backpack radiotags might be appropriate during nonbreeding periods, when waterfowl often are highly mobile; mortality factors such as hunting might be important; and aspects of waterfowl ecology of interest (e.g., movements, survival) might be less affected by behavioral abnormalities caused by external radiotags.

To test whether backpack radiotags impacted the wintering biology of female northern pintails (*A. acuta*) and are appropriate for study of nonbreeding dabbling ducks, I attached SSU (n=82 in 1991) or HAR backpack radiotags (n = 337 in 1991–1993) to female pintails after their autumn arrival in California and evaluated regional population distribution and August–March survival. In addition, because ducks that are in poor condition (Greenwood et al. 1986, Conroy et al. 1989) or alone (Olson 1965) might be more likely to be shot or killed than healthier individuals in flocks, I also compared flock status at harvest, flock size at harvest, and body mass at harvest for radiotagged and unmarked (UMK) pintails. Finally, I compared radiotag retention between SSU and HAR tagged female pintails.

Methods

I used rocket-nets (Schemnitz 1994) at rice-baited and unbaited wetland sites throughout the San Joaquin Valley (SJV), California (Fleskes et al. 2002*a*) to capture northern pintails during 28 August–6 October 1991, 31 August–5 October 1992, and 28 August–25 September 1993. I captured 4–275 ($\bar{x}$= 76) pintails in each of the 11–14 rocket-net shots each year and held all females and most males to maintain any existing pair bonds (Miller 1985). I weighed (±5 g), aged (Hatch-Year [HY] or After-Hatch-Year [AHY]; Carney 1992), and leg-banded all females. I radiotagged females in proportion to pintail abundance in the SJV as determined by September aerial surveys (G. Gerstenberg, California Department of Fish and Game, unpublished data) and released males and females together at the capture location <1–19 ($\bar{x}$=7.7) hours after capture. During 1991 and 1992, I exclusively attached 20–21-g (2.0–3.2% of body mass) back-mounted HAR radiotags (Dwyer 1972). In 1993 I radiotagged randomly selected pintails with either HAR (n = 103) or SSU radiotags (n=82). The SSU radiotags (Paquette et al. 1997, Zimmer 1997) weighed 8–9 g, had a circular (20-mm-diameter × 12-mm-high) body, and were attached as described by Pietz et al. (1995) but with a drop of cyanoacrylate glue added to suture knots. All radiotags were manufactured by Advanced Telemetry Systems, Incorporated, (470 First Avenue North, Isanti, Minn.) and had imprinted contact information, a unique frequency, a mortality sensor, life expectancy ≥210 days, and an initial minimum ground-to-ground range of 3.2 km using 150-db receivers and dual 4-element Yagi antennas mounted on the roof of vehicles. I requested that hunters report radiotagged pintails they shot in project descriptions posted at hunting check stations and in statewide media.

I recorded status (location, alive or dead) of each pintail 1–2 times a day during the hunting season, at least every other day during nonhunting seasons in the SJV, and weekly in other central California areas from capture until 20 March each year (202–205 days). Aerial searches (Gilmer et al. 1981) for missing pintails were conducted weekly throughout central California and 1–10 times each winter in other regions (Fleskes et al. 2002*a*). I attempted to recover all radiotags within 24 hours of hearing a mortality signal. I classified radiotags as shed if they were not on or near a pintail carcass or body parts and did not have shot, teeth, claw, or knife damage (Fleskes 1999). When estimating survival, I censored (i.e., excluded data thereafter) pintails on the date their radiotags were shed or when an intermittent, weakening, or increasingly fast or slow radiotag signal prevented daily tracking.



Spear-suture (bottom) and harness (top) backpack radiotags used on wintering female northern pintails (*Anas acuta*). Photo by author.

I also recorded deaths reported by hunters. I attempted to contact, either in the field or by phone, all hunters who shot a radiotagged pintail. I interviewed 63 hunters within 2 days of harvest about the flight altitude and movements (same as or different from other pintails), flock status (with or without ≥1 other pintail), and flock size of the radiotagged pintail. Fifty hunters reported flock status and flock size and allowed me to weigh 23 HAR and 3 SSU pintails they had shot. Throughout the hunting season, I interviewed 119 hunters at SJV public hunting areas who had harvested a female pintail, and I weighed 145 unmarked (UMK) pintails. Ninety-nine SJV hunters reported flock status and flock size of the UMK pintails they harvested. Except for 4 HAR pintails that were frozen and weighed 5–13 days later, I weighed all pintails on the day they were shot.

Duck hunting season in the California region, where almost all radiotagged pintails wintered, included a 22-day late-October to mid-November first season (Hunt-1) and a 37-day second season (Hunt-2) starting after a 12- (in 1991), 19- (in 1992), or 27- (in 1993) day closure (i.e., split) of duck hunting after the end of the first season. I further defined the season before Hunt-1 as Prehunt and after Hunt-2 as Posthunt.

Data analyses

I used a generalized linear model (McCullagh and Nelder 1989) across weeks, implemented through PROC GENMOD (SAS Institute 1997), which accounts for correlation between repeated measures (Liang and Zeger 1986), to compare weekly distribution within vs. outside SJV of SSU and HAR pintails. I also graphed UMK pintail abundance in SJV estimated with aerial surveys (Pacific Flyway waterfowl reports and United States Fish and Wildlife Service [USFWS], Portland, Oregon, USA, unpublished data). Because survival (Fleskes 1999), body mass (Miller 1986), and social status (Miller 1985) may vary by pintail age and among seasons and years, I tested for importance of these variables. I modeled (PROC LOGISTIC; SAS Institute 1997) frequency of pintails with ≥1 other pintail at time of harvest and used AIC_c values, corrected for small sample size (Akaike 1985, Burnham and Anderson 1992), to compare candidate models with or without radiotag status-type (SSU vs. HAR vs. UMK), pintail age (HY vs. AHY), and harvest interval (Oct–Nov vs. Dec–Jan). I modeled (PROC GLM; SAS Institute 1997) body mass of HAR and UMK pintails at harvest and change in HAR body mass between tagging and harvest, using AIC_c values to compare models with or without study year, radiotag status, pintail age, and harvest interval (too few SSU were weighed at harvest to model). To thoroughly investigate whether pintail survival varied by radiotag type, I followed up earlier known-fate modeling (Fleskes et al. 2002*b*) using program MARK (White and Burnham 1999), by focusing analysis on 1993–1994 when both radiotag types were used. I used AIC_c values to compare all possible models with and without radiotag type or radiotag type interacting with season, age, mass at capture, and age × capture mass (the only factors among numerous tested related to pintail survival during 1991–1994 earlier modeling). I used univariate analysis of variance (PROC GLM; SAS Institute 1997) to compare retention of SSU and HAR radiotags.

Results

Pintail distribution

Distribution of HAR and SSU pintails was similar most weeks, and, along with UMK pintails, most left the SJV during mid–late December (Figure 1) and flew north ~300 km to the Sacramento Valley. A week-by-radiotag type interaction ($\chi^2_1 = 3.59$, $P = 0.06$) might have been due to slightly earlier movement out of SJV by SSU pintails (Figure 1), but high failure and shedding of SSU radiotags complicated interpretation.

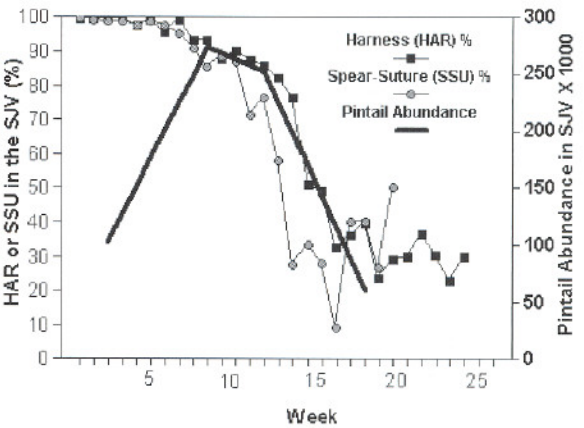


Figure 1. Abundance of unmarked pintails surveyed on 4 dates in San Joaquin Valley (SJV), California, and weekly % of live female northern pintails (*Anas acuta*) with functioning harness (HAR) or spear-suture (SSU) backpack radiotags that remained in SJV (region where radiotagged) during September–March, 1993–1994.

Flock status at harvest

Radiotagging did not affect flock status of pintails. Overall, 20% of SSU, 33% of HAR, and 39% of UMK females for which hunters reported on flock status were with ≥1 other pintail when shot. The 2 best-fitting models describing variation of whether pintails were or were not with ≥1 other pintails when harvested included pintail age and hunt interval with or without interaction (Total AIC_c weight [wt] = 0.56). Support was less for the 2 models that also included radiotag status-type (Total AIC_cwt = 0.35) and for a model that also included study year (AIC_cwt = 0.09). The odds of a pintail, at harvest, being with ≥1 other pintail was 4.87 (95% CI = 1.23–19.3) times greater for AHY than HY radiotagged pintails and 4.85 (95% CI = 1.22–19.3) times greater if harvested during December–January than October–November.

Flock size and flight at harvest

Flock size of female pintails with ≥1 other pintail at harvest was similar (t_{53} = 0.09, P = 0.93) for radiotagged ($\bar{x}$ = 3.87, SE = 0.57) and unmarked pintails ($\bar{x}$ = 3.54, SE = 0.65). Nearly all (60/63) hunters described flight of the radiotagged pintail they harvested as "normal," 2 said it was lowest in the flock, and 1 said flight movement was abnormal but noted it might have been crippled by another hunter.

Body mass at harvest

The best-fitting model describing variation in pintail harvest mass included radiotag-status (HAR vs. UMK), pintail age, harvest interval, and study year (AIC_cwt = 0.26). The same model, but without radiotag-status, was not supported by the data (AIC_cwt < 0.001). Averaged across all other factors, HAR pintails weighed 133 g (SE = 25 g) less than UMK pintails (t = 5.34, P < 0.0001) and HY pintails weighed 56 g (SE = 16 g) less than AHY pintails (t_{162} = 3.62, P < 0.0001) at time of harvest. Pintails shot during October–November averaged 30 g (SE = 17 g) more than during December–January (t_{162} = 1.80, P = 0.07) and pintails shot in 1993–1994 weighed less than in 1992–1993 (difference = 33 g, SE = 16 g, t_{162} = 2.11, P = 0.04) and 1991–1992 (difference = 44 g, SE = 38 g, t_{162} = 1.17, P = 0.24).

Change in body mass between tagging and harvest

The best-fitting model for body mass change of HAR pintails between tagging and harvest included body mass at capture and age (AIC_cwt = 0.31). All models within 2 AIC_c units of the best model included capture mass (capture mass alone AIC_cwt = 0.26; interacting with age AIC_cwt = 0.19; with study year AIC_cwt = 0.12). The interval during which the HAR pintail was shot or whether it was with ≥1 other pintail when shot was not closely related to mass change (AIC_cwt ≤ 0.07). Averaged across other factors, harvest mass decreased 0.9 g (SE = 0.2 g) for every g increase in capture mass. The AHY HAR females gained an average of 9 g (SE = 17 g), whereas HY HAR females lost (t_{23} = 1.78, P = 0.09) an average of 33 g (SE = 15 g). The HAR females tended to gain mass in 1991 ($\bar{x}$ = 12 g, SE = 17 g) and 1992 ($\bar{x}$ = 2 g, SE = 19 g) but lost mass in 1993 ($\bar{x}$ = 50 g, SE = 22 g). The 3 SSU pintails that were shot and weighed in 1993 lost 45 g (HY), 170 g (AHY), and 225 g (HY).

Pintail survival

Cumulative winter survival during 1993–1994 was 76.0% (95% CI = 60.2–86.9%) for AHY, 65.9% (95% CI = 51.2–78.0%) for HY, and 71.6% (95% CI = 60.9–80.3%) for females, overall. The best-fitting model for 1993–1994 pintail survival included only season and pintail age × capture mass (AIC_cwt = 0.58). Support was less for models that also included radiotag type (AIC_cwt = 0.21), or radiotag type interacting with pintail age (AIC_cwt = 0.13), mass at capture (AIC_cwt = 0.08), or season (AIC_cwt < 0.001). Daily survival rate (DSR) of HAR and SSU pintails was similar for both HY (HAR_{DSR} = 0.9979, 95% CI = 0.9965–0.9990; SSU_{DSR} = 0.9974, 95% CI = 0.9944–0.9993) and AHY (HAR_{DSR} = 0.9988, 95% CI = 0.9979–0.9996; SSU_{DSR} = 0.9986, 95% CI = 0.9968–0.9999) female pintails. Most mortalities

Releasing a radiotagged female northern pintail. Photo by Gary Zahm.

were from hunting (88%), and survival was consistently lower during hunting (DSR≤0.9963, 95% CI=0.9935–0.9979) than nonhunting seasons (DSR≥0.9986, 95% CI=0.9963–0.9995). Daily survival odds for an average-mass AHY female pintail were 33.4% (95% CI=-7.8–92.1%) greater than for an average-mass HY. Change in daily survival odds with each additional g at capture was not consistent for HY (20.2%, 95% CI=-21.9–91.4%) and AHY females (-29.0%, 95% CI=-59.0–23.0%).

Radiotag retention

Retention of radiotags ranged from 30–158 days ($\bar{x}$=81 d, SE=5 d) for 37 SSU that I confirmed as being shed; all other SSU failed <158 days (n=31) or were on pintails that died (n=14) <158 days (Figure 2). Only 2 (both in 1991) of 337 HAR were shed during the 202–205-day annual study across the 3 years.

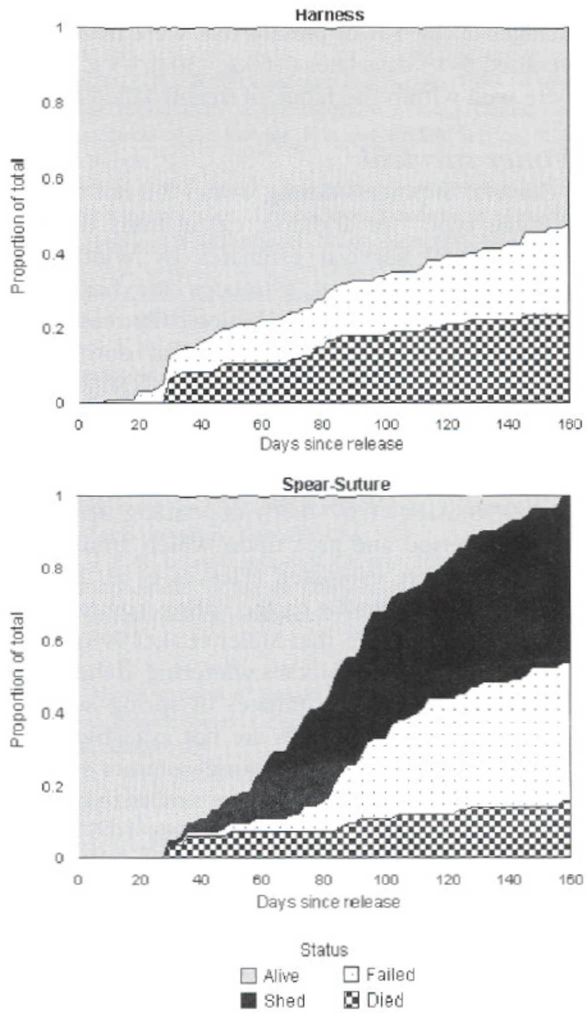


Figure 2. Status of female northern pintails (*Anas acuta*) 0–160 days after radiotagging with harness (n = 103) or spear-suture (n = 82) backpack radiotags in San Joaquin Valley (SJV), California, September–February, 1993–1994.

Discussion

Distribution and flocking behavior

Distribution of HAR, SSU, and UMK pintails was similar, indicating that neither radiotag type impacted regional movements. For instance, most radiotagged pintails left SJV during mid-December, which corresponded with the drop in the percent of pintails surveyed in central California in SJV. Normal movements of radiotagged pintails agreed with hunter reports of normal flight and flocking behavior of radiotagged pintails. Most other researchers who used HAR radiotags to study dabbling ducks during nonbreeding season also reported that radiotagged ducks generally flew, moved, and intermingled normally with other ducks (Conroy et al. 1989, Parker 1991, Bergan and Smith 1993). However, Reinecke et al. (1992) reported that although movements were normal, HAR mallards were less likely to be in large flocks and more likely to be alone when harvested than unmarked mallards.

Radiotag effects on body mass

The lighter harvest mass of HAR than UMK pintails and the mass loss by radiotagged pintails between tagging and harvest suggest that backpack radiotags affected body mass dynamics of pintails. However, decline in body mass during winter is normal in the Central Valley during some winters (Miller 1986). The magnitude and direction of change in pintail body mass between September and time of harvest is not known for UMK pintails, and the greater harvest mass of UMK pintails may reflect a greater starting mass in autumn rather than less change during winter. Regardless, my finding that heavier pintails lost more mass than lighter pintails indicates that body mass of pintails might have changed to compensate for HAR radiotags. Conroy et al. (1989) found losses of 16–18% of body mass from December to March for female black ducks (*A. rubripes*) with HAR backpacks compared to 5–7% for female black ducks without radiotags; others (Gilmer et al. 1974, Bowman and Longcore 1989, Houston and Greenwood 1993) reported no abnormal weight loss associated with radiotags. Thus, effects may vary by species, season, and environmental conditions (Burger et al. 1991). Mass changes of the 4 HAR pintails that were frozen and weighed 5-13 days later (+60 g, -30 g, +5 g, -20 g) were well within the range of freshly killed birds.

Winter survival

Survival of pintails during winter did not vary by radiotag type. In addition, calculations dividing mean annual survival estimates by winter (30 Aug-31 Mar) survival estimates for backpack-equipped pintails produce biologically reasonable estimates of female pintail survival during the spring-summer (1 Apr-29 Aug) period (Miller et al. 1995, Fleskes et al. 2002*b*). Calculated spring-summer survival estimates for female pintails averaged 0.80 for both HY and AHY but ranged widely (HY=0.63-0.98, AHY=0.67-0.86) depending upon the banding period and area upon which annual survival rates were estimated (Fleskes et al. 2002*b*). This estimate is similar to the spring-summer survival estimate of 0.75 that Miller et al. (1993) calculated for AHY female pintails wintering in the Sacramento Valley. Other estimates of spring-summer survival for female pintails are not available (Carlson et al. 1993), but most spring-summer survival estimates for female mallards are similar to my pintail estimates and also range widely (0.57-0.91; Johnson and Sargeant 1977, Cowardin et al. 1985, Kirby and Cowardin 1986, Reynolds et al. 1995).

Body mass of some female northern pintails with backpack radiotags did appear to be less than normal, and because pintail body mass in September-October is related to winter survival of HY females (Fleskes et al. 2002*b*), it is possible that backpack radiotags did reduce survival somewhat. However, even if radiotagging or wearing radiotags reduced pintail body mass, adjustments to survival estimates may be unnecessary if the body mass of pintails changed to compensate for the radiotag without any effect on survival. My finding that heavy birds were more likely than lighter birds to lose mass is consistent with this possibility.

Radiotag retention

Retention of SSU radiotags by wintering female pintails during this study (i.e., 1/80 shed by day 30, 20/80 shed by day 75, 24/80 shed by day 90) was better than for breeding northern shovelers (*A. clypeata*) (i.e., 20/42 shed during 30-day study; Zimmer 1997) but worse than for breeding mallards (≤13/198 shed during <90-day study; Paquette et al. 1997) carrying nearly identical SSU radiotags. Thus, morphological (e.g., skin thickness, body size) or

A female northern pintail with harness backpack radiotag. Photo by Gary Zahm.

behavioral (e.g., time spent preening or flying) differences related to species or time of year probably caused the differences in retention, although some subtle unreported differences in how radiotags were attached (e.g., angle of spear prongs, suturing, maintenance of sterile conditions, glue on skin) also could have affected retention. Pietz et al. (1995) reported even better retention than Paquette et al. (1997) on breeding gadwalls (*A. strepera*) (2/65 shed during 75-day study) and mallards (0/26 shed during 75-day study) equipped with smaller, 4-g SSU radiotags with a rectangular extension. Thus, use of SSU radiotags smaller in size and mass and with rectangular shape might improve retention on wintering pintails. Also, unlike others, Pietz et al. (1995) did not use glue on sutures because of the possibility that some glues could make sutures brittle or cause sloughing if applied to skin (P. Pietz, United States Geological Survey, personal communication). I was careful not to allow glue to reach skin, and all sutures were pliable and intact on SSU tags I recovered.

Management implications

Although backpack radiotags are not recommended for study of breeding waterfowl (Pietz et al. 1993, Rotella et al. 1993, Paquette et al. 1997), they provided relatively unbiased information on winter movement patterns and survival of female pintails. I recommend HAR rather than SSU radiotags for wintering pintail studies >1 month in duration because SSU radiotags provided no obvious survival or behavioral advantage and were poorly retained after 1 month. However, radiotags that are easy to attach, perform well for ≥6 months, and do not affect body mass dynamics are still needed for wintering waterfowl studies.

Acknowledgments. R. Jarvis, D. Gilmer, C. Meslow, J. Moore, C. Pereira, and W. Shephard provided advice that improved the study design. The staffs of Grassland Water District, San Luis and Kern National Wildlife Refuges, and Mendota and Los Banos Wildlife Areas provided housing and logistical support. M. Carriere of Busch Agriculture donated trapping rice. L. Belt, D. Breneman, D. Buford, M. Chouinard, Jr., C. Davis, R. Dunston, M. Humpert, P. Johnston, J. Laffitte, K. Mazacco, C. Stemler, and K. Young trapped and tracked pintails. California Department of Fish and Game donated flight costs. D. Orthmeyer, D. Yparraguirre, S. Blankenship, M. Miller, M. Casazza, B. Parkin, B. Conant, J McKay, D. Mauser, S. Boyd, B. Radke, W. Henry, R. Lowe, G. Ivey, and R. Migoya searched for radiotagged pintails. W. Perry and J. Daugherty provided GIS support. J. L. Lee provided extensive statistical support. Methods were reviewed extensively and approved by the Animal Care and Use Committee (ACUC) of the Northern Prairie Wildlife Research Center-Pacific States Ecology Section (later incorporated into the Western Ecological Research Center [WERC]). All ACUC procedures, as described in WERC's Animal Care and Use Committee Operating Policy-Standard Operating Procedure-8, were followed while conducting this project and in compliance with the Animal Welfare Act and United States Government Principles for the Utilization and Care of Vertebrate Animals Used in Testing, Research, and Training policies.

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Joseph P. Fleskes is a wildlife research biologist with the United States Geological Survey's Western Ecological Research Center stationed at Dixon, California. Joe earned his B.S. in fisheries and wildlife biology from Iowa State University in 1980, his M.S. in wildlife biology from Iowa State University in 1986, and his Ph.D. in wildlife science from Oregon State University in 1999. His research focus has been the ecology of migratory waterfowl and their predators and how they respond to landscape-scale habitat changes. Joe has conducted research in a variety of nesting, migration, and wintering habitats in North America with emphasis since 1986 in the Central Valley of California and other Pacific Flyway areas.

Associate editor: *Haukos*