JOURNAL OF FIELD ORNITHOLOGY

Published by
Association of Field Ornithologists

VOL. 65, NO. 2 | SPRING 1994 | PAGES 151–282

J. Field Ornithol., 65(2):151–159

INFLUENCE OF BROOD REARING ON FEMALE MALLARD SURVIVAL AND EFFECTS OF HARNESS-TYPE TRANSMITTERS

PETER J. BERGMANN, AND LESTER D. FLAKE

South Dakota State University
Department of Wildlife and Fisheries Sciences
P.O. Box 2140B
Brookings, South Dakota 57007 USA

W. LEE TUCKER

South Dakota State University
South Dakota Agricultural Experiment Station
Brookings, South Dakota 57007 USA

Abstract.—A total of 62 Mallard (*Anas platyrhynchos*) females were captured at their nests in eastern South Dakota during 1990 and 1991. Females were captured on an island, a peninsula cut off from the mainland by excavation, and a peninsula protected by an electric fence that deters mammals. Loop harnesses were used to attach radio transmitters to females to evaluate possible effects of marking females on survival of their ducklings and to determine the influence of brood rearing on female survival. No difference was found in duckling ($P = 0.999$) or brood ($P = 0.458$) (e.g., one or more ducklings alive in brood) survival to 7 d for females marked from 1 d prior to hatch to immediately post hatch (still in nest) compared with those marked at 3–9 d before hatch ($P = 0.081$). There also were no differences in survival by age class between marked broods that did not suffer total mortality and unmarked broods ($P > 0.05$). If survival of broods was influenced by harness attachments on females, it likely occurred in females suffering total brood loss early in brood rearing. Marked females with broods had poorer survival to 21 d than marked females that had lost or abandoned their clutches or broods (73.5% vs. 100%, $P < 0.001$).

EVALUACIÓN DEL EFECTO DE TRANSMISORES EN ARNESES EN LA CRIANZA DE PATITOS Y EN LA SUPERVIVENCIA DE HEMBRAS DE *ANAS PLATYRHYNCHOS*

Sinopsis.—Durante el 1990 y 1991 se capturaron, en sus nidos, un total de 62 individuos de *Anas platyrhynchos* en un estudio que se llevó a cabo en Dakota del Sur. Las hembras fueron capturadas en islas, penínsulas separadas por excavación de tierra firme y una península protegida de mamíferos depredadores por una verja electrificada. Se utilizaron arneses en forma de lazo para montar los radiotransmisores a hembras y evaluar el posible efecto de los artefactos en la supervivencia de los patitos y la influencia de la crianza en la supervivencia de la hembra. No se encontraron diferencias significativas en la supervivencia de patitos ($P = 0.999$) o camadas ($P = 0.458$) (ej. uno o más patitos vivos en cada camada) hasta los siete días de edad para hembras marcadas el día previo al eclosionamiento o un día inmediatamente después (todavía en el nido) esto en comparación a hembras a las cuales se les colocó el radiotransmisor 3–9 días previo al eclosionamiento ($P = 0.081$). Tampoco se encontró diferencia en la supervivencia de patitos (arreglados en grupos por edades) entre camadas que no sufrieron mortalidad total y camadas no marcadas ($P > 0.05$). Si acaso hubo influencia de los radiotransmisores en la supervivencia de las camadas, ésta ocurrió en hembras que perdieron toda la camada poco tiempo después del eclosionamiento. Las hembras con camadas, que fueron marcadas, tuvieron una supervivencia menor (hasta los 21 días), que aquellas (también con radiotransmisores) que perdieron o abandonaron sus nidos o sus patitos a bien temprana edad (73.5% vs. 100%, $P < 0.001$).

An assumption in most radio-telemetry studies is that animals are unaffected by transmitters and thus behave similarly to non-instrumented animals (White and Garrott 1990). In most studies of waterfowl reproduction that have used radio-telemetry, few or no effects of transmitters on females were observed (Ball et al. 1975, Cowardin et al. 1985, Duncan 1986, Orthmeyer and Ball 1990). Most studies do not measure effects of radio-transmitters; however, possible adverse effects of radio-packages on Mallards and other waterfowl species have been reported (Chabaylo 1990, Gilmer et al. 1974, Greenwood and Sargeant 1973, Perry 1981).

Rotella and Ratti (1992) attached transmitters to Mallard (*Anas platyrhynchos*) females using the loop harness (Dwyer 1972) and observed no effects on brood or female survival. They cautioned that effects may not be evident for females losing broods soon after hatch. Others working with loop harnesses are finding possible negative effects of this type of transmitter attachment (Pietz et al. 1993, Reinecke et al. 1992, Rotella et al. 1993).

In waterfowl brood-survival studies, females are often fitted with transmitters several days (or more) prior to predicted hatch to allow a period of adjustment (Orthmeyer and Ball 1990, Rotella and Ratti 1992, Talent et al. 1983) and reduce possible effects of the transmitter on female behavior (Gilmer et al. 1974). Given the high rates of nest destruction (Klett et al. 1988), however, females marked later in incubation are more likely to hatch their clutches and provide information on survival of ducklings and broods.

Survival of Mallard females could be greatly influenced by their brood-rearing activities. Females are at risk of increased predation during nesting (Sargeant et al. 1984) and brood rearing as they place themselves in habitats not regularly frequented except during the reproductive period (Cowardin et al. 1985, Kirby and Cowardin 1986, Sargeant et al. 1984).

During a study of Mallard brood ecology, we used the loop harness to attach transmitters to 62 nesting females. Our objectives were to: (1) determine if nesting females fitted with radio-transmitters near the hatch date suffered higher duckling or brood mortality than those marked earlier in incubation; (2) determine if survival rates in broods of radio-transmittered females, excluding those suffering total brood loss, were different from unmarked broods of similar age; and (3) compare survival of marked females with and without broods to determine if survival was influenced by brood-rearing activities. We also observed radio-marked females that

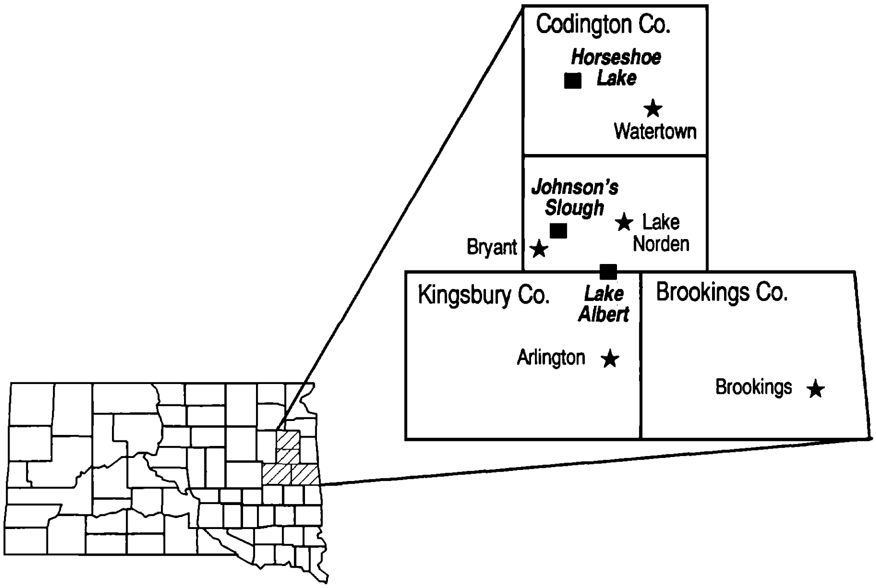

FIGURE 1. Location of Lake Albert, Johnson's Slough and Horseshoe Lake study areas in east central South Dakota.

abandoned or otherwise lost their nests late in incubation or lost their entire broods to determine if re-nesting occurred.

STUDY AREA AND METHODS

Our study was conducted during 1991 and 1992 within the Coteau des Prairie physiographic region of east-central South Dakota, an area with abundant glacial wetlands. Mallard females were captured on the nest in three predator-reduced habitats: a natural island (Lake Albert Island), a peninsula cut off from the mainland by excavation (Johnson's Slough), and a peninsula largely protected from mammalian nest predators by an electric fence (Horseshoe Lake) (Fig. 1). The three nesting areas were on public lands managed by the South Dakota Department of Game, Fish and Parks.

Three methods were used to capture females: purse-string traps (Coulter 1958), bow-net traps (Salyer 1962), and walk-in traps (Dietz et al. 1994). The walk-in trap was effective in capturing females at hatch without causing injury to the ducklings. Females were captured 1–9 d prior to the predicted hatch date or at hatch. Females were fitted with back-pack style radio transmitters (Advanced Telemetry Systems, Isanti, Minnesota) weighing 20–23 g using loop attachments (Dwyer 1972). To reduce nest abandonment after capture, females were anesthetized with methoxyflurane (Metafane) (Rotella and Ratti 1990), and returned to the nest.

Radio signals were received with hand-held antennas and with a null yagi antenna system mounted on a truck; triangulation was used to estimate locations of radio-marked females. Whenever possible, radio signal contact was verified at least once and more often twice per day for each female and brood. Females experiencing total brood loss, or losing or abandoning nests after capture, were tracked as long as possible to determine if re-nesting occurred. Conclusions that females lost broods were based on direct observation and female behavior (Orthmeyer and Ball 1990, Rotella and Ratti 1992).

Marked females with broods were observed from distant or hidden vantage points at weekly intervals, or more often when possible, to determine duckling mortality. Observations were made with a spotting scope or binoculars from sunrise until 1000 hours and from 1800 hours until dark, when waterfowl broods were most active (Beard 1964, Ringelman and Flake 1980). We assumed any broods abandoned by marked females in the first week post hatch sustained 100% mortality near the time of abandonment.

Age class (Gollop and Marshall 1954) and number of ducklings with marked or unmarked females were recorded during observations of ponds with marked birds. Additional wetlands in the general study area, other than those in use by radio-transmittered females, were observed to increase our sample size of unmarked broods.

Two analyses were used to determine if a transmitter affected a female's ability to rear her ducklings. In the first, incubation stage at capture was used to divide females into two groups. One group included females captured on their nests from 1 d prior to their clutch hatching to 1 d after hatching (late marked). The second group included those females captured 3–9 d prior to their clutches hatching (early marked).

Duckling and brood survival were estimated for the first week post hatch and compared between these two groups; a brood was considered to have survived as long as at least one duckling was alive. Partial mortality of broods as indicated by reduced brood size and complete loss of broods were both considered in the calculation of duckling mortality.

In the second analysis we compared sizes of broods of similar age between marked and unmarked females; this analysis did not take total brood loss into account because such loss is not detectable in unmarked females. In our analysis we used brood size for marked broods only the first time observed within an age class. The first complete count of ducklings with marked females within each age class varied greatly from early to late within an age class. We also attempted to use unmarked broods on wetlands watched more than one time only the first time they were observed within an age class; identification of individual unmarked broods was based on brood age and size.

Data analysis.—Adult female and brood survival rates were estimated using the modified Mayfield method (Mayfield 1975) and the microcomputer program Micromort version 1.3 (Heisey and Fuller 1985). Sample size was equal to the number of brood and female survival days (one female or one brood surviving 1 d). Statistical z tests were used to compare

TABLE 1. Comparison of survival rates to 7 d post hatch for broods[a] and ducklings of Mallards captured at the nest and fitted with a loop harness and back-pack transmitter (Dwyer 1972) from 1 d before to 1 d after hatch (late marked) and from 3–9 d before hatch (early marked).

Brood or duckling fates	Treatments		Early vs late comparison
	Late marked	Early marked	
Broods			
# surviving to 7 d	16	14	
# dying by 7 d	4	3	
Interval (7 d) survival rate (±1 SD)[b]	0.816 (0.094)	0.793 (0.089)	$P = 0.458$
Ducklings			
% of ducklings hatched surviving to 7 d (n)[c]	54.5% (16)	59.3% (12)	$P = 0.999$[d]

[a] A brood was considered to have survived if at least one duckling was alive at 7 d after hatch.

[b] Survival estimated using Micromort program (Heisey and Fuller 1985); means were compared using a z statistic.

[c] Duckling mortality was not normally distributed. This percentage represents the total ducklings alive at 7 d/total ducklings hatched × 100 for 16 early marked and 12 late marked females. Sample size (n) is the number of broods for which accurate duckling counts were available 7-d post hatch.

[d] Percentages of ducklings within broods surviving to 7 d or early versus late marked were compared using a median test and chi-squared test of independence.

interval (7 d) survival rates for broods of early versus late marked females. A z test was also used to compare survival of females with broods versus females without broods (failed nests or broods).

Duckling survival rates within each brood were based on percentage of the ducklings alive at 7 d. Percentage of ducklings alive at 7 d was compared for broods of females marked late versus early with a median test. Sample sizes in our comparisons of duckling mortality were equal to numbers of broods, not ducklings (Rotella and Ratti 1992). We did not use Micromort to estimate duckling survival because the mortality of ducklings within broods was not independent of broodmates.

Analysis of variance (Fisher's least-significant difference) was used to compare brood size for different age classes of marked and unmarked broods (SAS 1989).

RESULTS

We detected no differences in brood ($P = 0.458$) or duckling ($P = 0.999$) survival between broods of females captured later in incubation versus those captured earlier (Table 1). For broods, at least one duckling survived to 7 d in 16 of 20 broods for late marked; one or more ducklings survived to 7 d in 14 of 17 broods for early marked females. Brood survival rates for the 7-d interval were almost identical between early and late marked females (Table 1). Of all ducklings hatched, 54.5% of the late

TABLE 2. Average size of marked and unmarked Mallard broods by age class (Gollop and Marshall 1954) for radio-marked and unmarked females for the eastern South Dakota study area, 1990–1991.

Age class/ brood type	n[a]	x̄	SE	P[b]
IA (1–7 d)				
Marked	43	7.60	0.42	0.500
Unmarked	51	7.22	0.39	
IB (8–13 d)				
Marked	23	6.56	0.49	0.752
Unmarked	39	6.33	0.48	
IC (14–18 d)				
Marked	18	6.56	0.62	0.654
Unmarked	32	6.19	0.44	
IIA (19–27 d)				
Marked	12	6.50	0.83	0.968
Unmarked	26	6.46	0.48	
IIB (28–36 d)				
Marked	12	6.17	0.84	0.802
Unmarked	26	5.92	0.61	
IIC (37–42 d)				
Marked	11	5.73	0.92	0.452
Unmarked	30	6.47	0.49	
III (43–60 d)				
Marked	10	5.60	1.01	0.747
Unmarked	55	5.91	0.38	

[a] Repeated observations of marked and unmarked broods (when identifiable) within one age class deleted from the analysis.
[b] Fisher's least-significant difference was used to compare between marked and unmarked broods within the same age class.

marked ducklings and 59.3% of the early marked ducklings survived at least 7 d.

We found no differences in brood size by age class (ANOVA) between broods of marked and unmarked females ($P > 0.05$; see Table 2 for P values by age class).

During the study, 11 radio-marked Mallard females losing or abandoning their nests after capture, and 16 females losing their entire broods, remained near the study area for at least 3 wk. We detected no renesting in females with failed nests or broods in either year. Of the 27 Mallard females without broods, none died or were killed while monitored over this 3-wk period. Twelve nesting or brood-rearing females of 62 fitted with transmitters were killed by predators. Of these 12 females, two were killed on the nest before hatch and 10 were killed after hatching. Nine of the 10 females with broods were killed, apparently by predators, in the first 21 d after their clutches hatched. The survival estimate for brood females to 21 d was 0.735 (95% CIs = 0.599–0.901). A z test indicated lower survival for marked females with broods ($z = 3.52$, $P < 0.001$) than for marked females that had lost their nests or broods.

DISCUSSION

In our study, Mallard females were captured on the nest between 9 d prior to and 1 d after hatch; it is possible that females captured and marked near the hatch date were still adjusting to the radio-package and therefore less attentive to their broods. Lack of attentiveness could lead to increased mortality rates among ducklings of females marked at or near hatching. Gilmer et al. (1974) recorded an increase in comfort movements (preening, stretching and shaking) in Mallards in the first few days after marking them with loop harnesses and breast-mounted transmitters. Our data indicate, however, that overall survival for broods and ducklings to 7 d for brooding females captured late in incubation (1 d prior to hatch to 1 d after) was as high or higher than that for females captured earlier (3–9 d prior to hatch).

Mallard females fitted with harness-type transmitter attachments will not renest as readily as those fitted with some other types such as implants and sutured backpacks (Rotella et al. 1993). Females losing their clutches in late incubation or losing their broods would be expected to require a longer interval before renesting than those losing clutches early in incubation (Swanson et al. 1986). Doty (1975) recorded renesting in wild Mallards that had previously hatched clutches and lost their entire broods. Thus, the complete lack of renesting among Mallard females that had nesting or brood-rearing failures may be unusual and due to effects of the loop attachment and radio transmitter.

We observed no differences in brood size of surviving broods by age class (Gollop and Marshall 1954) for marked and unmarked females. Ball et al. (1975) found no differences in size of Wood Duck (*Aix sponsa*) and Mallard broods (by age in weeks) between unmarked females and females fitted with body loops and breast-mounted transmitters. We emphasize that comparison of brood size would not reveal possible differences between marked and unmarked females due to loss of entire broods. Rotella and Ratti (1992) suggested that transmitter attachments on brooding females, if causing increased duckling mortality, may be related to early loss of entire broods.

Predation during nesting is considered an important factor in the annual survival of female waterfowl (Sargeant et al. 1984). Females also are at risk from predation while raising broods, particularly from mink (*Mustela vison*) (Cowardin et al. 1985). Of 10 females with broods where the female was apparently killed by predators, six showed bite marks to the back of the skull and some were cached, all indications of mink predation (Sargeant et al. 1973, Yeager 1943). Two marked females were killed immediately post hatch while leading their broods from Lake Albert Island. These two females were decapitated and stripped of flesh on the breast, we suspect by a Great Horned Owl (*Bubo virginianus*) that had been observed frequently on the island.

Kirby and Cowardin (1986) reported Mallard female survival, during 51 d of brood rearing, at 0.943. Cowardin et al. (1985) found Mallard female survival from April to June was 0.874 and from July to September was 0.806. Johnson and Sargeant (1977) recorded the lowest summer survival rate for females at 0.692. Our survival estimate for brood-rearing females (0.735) to 21 d after hatch seems somewhat low when compared to these previous estimates especially because these estimates are for longer periods. The estimate for brood-rearing females is low compared to the 100% survival in females that had been unsuccessful in nesting or had lost their broods. We conclude that females with broods are at considerably greater risk of death, primarily by predation, than those without broods.

CONCLUSIONS

We could find no evidence that Mallard females given more time to adjust to transmitters before hatch were more successful in rearing ducklings to 7 d post hatch. Broods of females with harness-attached transmitters were as large as similar aged broods of unmarked females. If survival of Mallard ducklings was influenced by the harness attachments on brood females, it likely occurred in females suffering total brood loss early in brood rearing. Mallard females with broods appeared to have considerably lower survival than females that had abandoned or otherwise lost their clutches or broods (75% vs. 100% survival rate over 21 d).

ACKNOWLEDGMENTS

We thank P. Pietz and J. Jenks for reviewing this manuscript, and P. Beauzay, J. Gleason, S. Bierle and G. Wiesbrich for assisting with data collection. Funding was provided by the Gay Simpson Memorial Scholarship through Ducks Unlimited's Institute for Wetland and Waterfowl Research; the South Dakota Department of Game, Fish and Parks; and Federal Aid in Wildlife Restoration (Project W-75-R, Study 7549). Ducks Unlimited provided financial and engineering support for formation of the island at Johnson Slough and development of the electric fence at Horseshoe Lake.

LITERATURE CITED

BALL, I. J., D. S. GILMER, L. M. COWARDIN, AND J. H. RIECHMANN. 1975. Survival of wood duck and mallard broods in north-central Minnesota. J. Wildl. Manage. 39:776–780.

BEARD, E. B. 1964. Duck brood behavior at the Seney National Wildlife Refuge. J. Wildl. Manage. 28:492–521.

CHABAYLO, R. M. 1990. The impact of radiotelemetry on mallard reproductive success. M.Sc. thesis, Univ. Alberta, Edmonton, Alberta, Canada.

COULTER, M. W. 1958. A new waterfowl nest trap. Bird-Banding. 29:236–241.

COWARDIN, L. M., D. S. GILMER, AND C. W. SHAIFFER. 1985. Mallard recruitment in the agricultural environment of North Dakota. Wildl. Monogr. 92.

DIETZ, N. J., P. J. BERGMANN, AND L. D. FLAKE. 1994. A walk-in trap for nesting ducks. Wildl. Soc. Bull. 22:19–22.

DOTY, H. A. 1975. Renesting and second broods of wild mallards. Wilson Bull. 87:115.

DUNCAN, D. C. 1986. Survival of dabbling duck broods on prairie impoundments in southeastern Alberta. Can. Field-Nat. 100:110–113.

DWYER, T. J. 1972. An adjustable radio package for ducks. Bird-Banding. 43:282–284.
GILMER, D. S., I. J. BALL, L. M. COWARDIN, AND J. H. RIECHMANN. 1974. Effects of radio packages on wild ducks. J. Wildl. Manage. 38:243–252.
GOLLOP, J. B., AND W. H. MARSHALL. 1954. A guide for aging duck broods in the field. Mississippi Flyway Council Tech. Sect. Rep.
GREENWOOD, R. J., AND A. B. SARGEANT. 1973. Influence of radio packs on captive mallards and blue-winged teal. J. Wildl. Manage. 37:3–9.
HEISEY, D. M., AND T. K. FULLER. 1985. Evaluation of survival and cause-specific mortality rates using telemetry data. J. Wildl. Manage. 49:668–674.
JOHNSON, D. H., AND A. B. SARGEANT. 1977. Impact of red fox predation on the sex ratio of prairie mallards. U.S. Fish and Wildl. Serv. Wildl. Res. Rep. 6.
KIRBY, R. E., AND L. M. COWARDIN. 1986. Spring and summer survival of female mallards from northcentral Minnesota. J. Wildl. Manage. 50:38–43.
KLETT, A. T., T. L. SHAFFER, AND D. H. JOHNSON. 1988. Duck nest success in the prairie pothole region. J. Wildl. Manage. 52:431–440.
MAYFIELD, H. 1975. Suggestions for calculating nest success. Wilson Bull. 87:456–466.
ORTHMEYER, D. L., AND I. J. BALL. 1990. Survival of mallard broods on Benton Lake National Wildlife Refuge in northcentral Montana. J. Wildl. Manage. 54:62–66.
PERRY, M. C. 1981. Abnormal behavior of canvasbacks equipped with radio transmitters. J. Wildl. Manage. 45:786–789.
PIETZ, P. J., G. L. KRAPU, R. J. GREENWOOD, AND J. T. LOKEMOEN. 1993. Effects of harness transmitters on behavior and reproduction of wild mallards. J. Wildl. Manage. 57:696–703.
REINECKE, K. J., C. W. SHAIFFER, AND D. DELNICKI. 1992. Band reporting rates of mallards in the Mississippi Alluvial Valley. J. Wildl. Manage. 56:526–531.
RINGELMAN, J. K., AND L. D. FLAKE. 1980. Diurnal visibility and activity of blue-winged teal and mallard broods. J. Wildl. Manage. 44:822–829.
ROTELLA, J. J., D. W. HOWERTER, T. P. SANKOWSKI, AND J. H. DEVRIES. 1993. Nesting effort by wild mallards with 3 types of radio transmitters. J. Wildl. Manage. 57:690–695.
———, AND J. T. RATTI. 1990. Use of methoxyflurane to reduce nest abandonment of mallards. J. Wildl. Manage. 54:627–628.
———, AND ———. 1992. Mallard brood survival and wetland habitat conditions in southwestern Manitoba. J. Wildl. Manage. 56:499–507.
SAS. 1989. SAS Institute, Inc. SAS/STAT user's guide, Version 6, 4th ed., Vol. 2. Cary, North Carolina. 846 pp.
SALYER, J. W. 1962. A bow-net trap for ducks. J. Wildl. Manage. 26:219–221.
SARGEANT, A. B., G. A. SWANSON, H. A. DOTY. 1973. Selective predation by mink, *Mustela vison,* on waterfowl. Am. Midl. Nat. 89:208–214.
SARGEANT, S. H., S. H. ALLEN, AND R. T. EBERHARDT. 1984. Red fox predation on breeding ducks in midcontinent North America. Wildl. Monogr. 89.
SWANSON, G. A., T. L. SHAFFER, J. F. WOLF, AND F. B. LEE. 1986. Renesting characteristics of captive mallards on experimental ponds. J. Wildl. Manage. 50:32–38.
TALENT, L. G., R. L. JARVIS, AND G. L. KRAPU. 1983. Survival of Mallard broods in south-central North Dakota. Condor 85:74–78.
WHITE, G. C., AND R. A. GARROTT. 1990. Analysis of wildlife radio-tracking data. Academic Press, San Diego, California. 383 pp.
YEAGER, L. E. 1943. Storing muskrats and other foods by minks. J. Mammal. 24:100–101.

Received 23 Dec. 1992; accepted 22 Mar. 1993.