Tools and Technology

Ear Tag and PIT Tag Retention by White-tailed Deer

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ABSTRACT White-tailed deer (*Odocoileus virginianus*) have been marked with various tags for a wide variety of applications, such as longitudinal, movement, disease, and mark–recapture studies. Tag persistence is critical to all these applications. We used nest survival models in Program MARK to estimate tag retention from 1) 832 free-range white-tailed deer marked with large plastic ear tags in both ears and Passive Integrated Transponder (PIT) tags in the leg and at the base of the ear, and 2) 412 free-range deer marked with metal ear tags in both ears, captured in Texas, USA, 1997–2007. We calculated tag retention from 401 captive deer marked with 2 types of Electronic Identification (EID) ear tags (button or combi) in one ear and 36 captive deer marked with small plastic ear tags in one ear. Annual retention rates were greatest for button EID tags (0.992; 0.983–0.998), combi EID tags (0.979; 0.953–0.996), small plastic ear tags (0.978; 0.965–0.995), and large plastic ear tags (0.958; 0.950–0.965). Passive integrated transponder tags at the base of the ear (0.923; 0.910–0.935) and metal tags (0.909; 0.891–0.924) had fair retention rates. Passive integrated transponder tags placed in the leg (0.779; 0.758–0.800) had the lowest retention rate. Although many factors influence tag selection, EID tags and both small and large plastic tags demonstrate the greatest annual retention rates of both captive and free-range, marked deer.

KEY WORDS ear tag, EID tag, metal tag, *Odocoileus virginianus*, PIT tag, tag retention, white-tailed deer.

The ability to recognize individual white-tailed deer (*Odocoileus virginianus*) can be valuable in many research and management settings. Although other methods exist, tags are commonly used to mark livestock and wildlife so that individuals can be monitored. Some markings, such as plastic ear tags, can be easily read from a distance or in trail-camera photos. Although exposure to sunlight and other elements can cause tag color to fade, making color difficult to determine, plastic tags remain reliable because the tag number generally does not fade. Other markings, such as metal ear tags or Passive Integrated Transponder (PIT) tags, can only be read within close proximity and, therefore, require recapture of animals (Silvy et al. 2012).

Electronic tags are an additional option for marking deer. Information stored in electronic tags is accessed using a scanner or reader. Electronic Identification (EID) tags are often produced as a visible, plastic "button" ear tag. There are several types of EID tags, including button tags that are small, round tags, and combi tags that have a "button" combined with a larger, numbered plastic tag. Passive integrated transponder tags are inserted under the skin of the animal and consist of a microchip inside a glass housing. An advantage of PIT tags is that they are a nonvisible marking, which may be desirable under some circumstances (Silvy et al. 2012). One disadvantage of PIT tags is that if not inserted properly, the glass can crack during insertion, affecting the readability of the PIT tag (Lambooij et al. 1995). Exposure to blunt force could also cause the glass to crack. Additionally, the PIT tag could slip out of the opening in the skin created by the needle (Lambooij et al. 1995). There could be a learning curve for properly implanting

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PIT tags, which may influence PIT tag retention (Conill et al. 2000).

Both free-range and captive white-tailed deer have been marked with tags for a variety of objectives. Tags are often used on captive white-tailed deer, such as deer in research facilities (DeNicola et al. 1997, Cohen et al. 2014). Many states require captive deer to be marked with visible, plastic ear tags to distinguish individuals in herd monitoring procedures. Individual identification is important for accurate records, monitoring disease, research protocols, and establishing breeding programs to meet the facility's goals. Research projects have used tags in free-range deer for assessing individual deer behavior, recording population trends, and estimating survival rates (Severinghaus 1949, Campbell et al. 2005, Page and Underwood 2006, Rhoads et al. 2010, Clements et al. 2011). Although many tag types are available, retention rates are critical to meet research and management goals. For example, loss of ear tags may result in overestimates of population size and mortality (Nelson et al. 1980, Seber 1982). A common use of ear tags in white-tailed deer is mark–recapture or mark–resight studies, which can be used to estimate population size and structure (DeYoung 1985, Curtis et al. 2009). One of the critical assumptions of mark–recapture is that tags or marks are never lost. We wanted to test whether this assumption was satisfied by various ear tags and PIT tags used on white-tailed deer.

Although retention of tags in aquatic species (Gries and Letcher 2002, Dunning et al. 2011) and livestock (Hasker et al. 1992, Lamboolj et al. 1995, Conill et al. 2000) is well-documented, published data on tag retention, particularly electronic tags, in white-tailed deer are lacking (Harper and Lightfoot 1966, Downing and McGinnes 1969, Beasom and Burd 1983). Tags are widely used for deer; therefore, estimated annual retention rates are important in understanding the reliability of these tags. We used data from captive and free-range white-tailed deer in Texas, USA, to estimate annual retention rates of large and small plastic ear tags, metal ear tags, button and combi EID ear tags, and PIT tags placed at the base of the ear or in the leg. We also investigated annual retention rates of PIT tags inserted by inexperienced personnel compared with experienced personnel because we hypothesized that experience with PIT tag insertion could affect PIT tag survival.

STUDY AREAS

Small Plastic Ear Tags

White-tailed deer were housed at the Alkek Captive Ungulate Facility at Texas A&M University-Kingsville in Kingsville, Texas, from June 2004 through February 2015. We maintained deer in research enclosures ranging in size from 0.1 to 0.4 ha and surrounded by a 2.4-m net-wire fence. All enclosures contained cactus and native woody plants including prickly pear (*Opuntia* spp.) and honey mesquite (*Prosopis glandulosa*).

Electronic Identification Tags

We collected data from deer housed in the Donnie E. Harmel White-tailed Deer Research Facility on the Kerr Wildlife Management Area (WMA) in Kerr County, Texas, during 2012–2015. The facility was enclosed and partitioned by a 2.7-m-high game fence, including breeding (0.3 ha) and rearing (0.5–1.6 ha) pens (Lockwood et al. 2007). Pens contained widely spaced live oak (*Quercus virginiana*) trees.

Large Plastic Ear Tags and Passive Integrated Transponder Tags

We collected data annually on 5 study sites in southern Texas from October 1997 to November 2007. One study site (Kleberg 1) was located 25 km east of Kingsville, Texas, in Kleberg County. This 7,729-ha tract was mixed-shrub rangeland dominated by honey mesquite and huisache (*Vachellia farnesiana farnesiana*) in the Texas–Tamaulipan Thorn Scrub ecoregion of the South Texas Plains (Griffith et al. 2004). The other 4 sites (Webb 1–4) were located in Webb County in the Texas–Tamaulipan ecoregion, east and northeast of Laredo, Texas. The Webb County study sites were dominated by mesquite and ranged in size from 4,937 ha to 34,400 ha, although captures were concentrated on areas from 4,937 ha to 10,117 ha. Kleberg 1 and Webb 1 were surrounded by $\leq$1.5 m livestock fences. Webb 2 had a 2.4-m net-wire fence on 2 sides, a livestock fence on half the third side, and a state highway on the fourth side. Webb 3 and Webb 4 were enclosed by a 2.4-m net-wire fence (Hewitt et al. 2014).

Metal Ear Tags

We collected data annually from free-ranging deer during October 2011 to November 2014 on 4 properties of the East Foundation in South Texas: the El Sauz Ranch, the Santa Rosa Ranch, the Buena Vista Ranch, and the San Antonio Viejo Ranch. The El Sauz, Santa Rosa, and Buena Vista ranches ranged in size from 6,109 to 11,082 ha, were in Willacy, Kenedy, and Jim Hogg counties, Texas, respectively, and were located in the Coastal Sand Plain ecoregion of the South Texas Plains (Griffith et al. 2004). The San Antonio Viejo Ranch was 60,179 ha in Jim Hogg and Starr counties, Texas, and was in the Coastal Sand Plain and Texas–Tamaulipan Thorn Scrub ecoregions of the South Texas Plains (Griffith et al. 2004).

METHODS

Deer Capture and Tag Placement

Small plastic ear tags.—Beginning in June 2004, we marked captive male and female fawns approximately 3 months old with one numbered, plastic, 5 × 4-cm ear tag (Y-Tex All American ear tag; Y-Tex, Cody, WY, USA) placed in the right ear between the cartilage ribs about a quarter of the distance from the head (Buskirk 2006) with an applicator (Y-Tex UltraTagger Applicator). We handled deer using a chute system. We monitored each deer throughout its life and recorded when ear tags were lost. We replaced lost ear tags; thus, the number of tags used was greater than the number of deer for this and some of the following data sets. Deer handling was approved by Texas A&M University-Kingsville (TAMUK) Institutional Animal Care and Use Committee (IACUC; protocols 2003-6-5, 2009-07-16A and 2015-06-22).

Electronic Identification tags.—We handled male and female captive deer using a rotunda and chute system annually in October. We deployed a combi EID tag (CombiE23^{TM}; Allflex USA Inc., Dallas, TX, USA) or a button EID tag (Allflex LW FDX^{TM}; Allflex USA, Inc.) in the right ear of each fawn approximately 4–5 months old (Buskirk 2006). Electronic identification tags were 25−30 mm in diameter and weighed 4−8 g. We attached buttons with a male tag backing pierced through the ear and fastened into the female-fitted EID button. We reversed combi EID tag placement so the female fitted end was exposed posteriorly, and only the button backing was exposed in all other deployments. We used a Bluetooth (Bluetooth Special Interest Group, Kirkland, WA, USA) −compatible handheld wand, (RS 240HD; Allflex USA, Inc.) to read EID tags during handling of all deer (Texas Parks and Wildlife Department-Kerr WMA IACUC Protocol No. 2209252012).

Large plastic ear tags.—We captured free-ranging male deer during autumn using a helicopter and net-gun capture technique (Webb et al. 2008). We captured deer as they were encountered by the helicopter pilot, without selection for capture history. This enabled us to capture deer that may have lost both tags. We restrained and blindfolded captured deer and placed large colored and numbered ear tags (Maxi 7.62 cm × 10.16 cm; Allflex USA, Inc.) in both ears on newly captured deer at the Webb County study sites, except for 2003–2004 when we placed tags in only the right ear (Buskirk 2006, Hewitt et al. 2014). We applied tags using a Universal Total Tagger (Allflex USA, Inc.). We obtained annual-retention-rate data from deer when they were recaptured or harvested in subsequent years, although tagged deer were not necessarily recaptured annually (TAMUK IACUC protocols 3-98-09, 99-5-2, 2003-5-14). Hunters were required to bring harvested deer to a check station on each study site, where a biologist recorded tag information.

Passive Integrated Transponder tags.—We inserted PIT tags in the same deer that had received the large plastic ear tags. We inserted 2 12-mm PIT tags (Avid Identification Systems, Norco, CA, USA) using a 12-gauge needle in each deer. Every deer received one PIT tag at the base of the right ear. We placed a second PIT tag in the right leg, 10 cm above the hoof. At the Kleberg County study site, experienced personnel with the Texas Parks and Wildlife Department implanted PIT tags. Personnel at the Webb County study sites had little to no experience implanting PIT tags and were trained in the field. We read PIT tags using a Power TracKer II tag reader (Avid Identification Systems, Norco, CA).

Metal ear tags.—We captured male and female free-ranging deer of all ages using the helicopter–net-gun capture (Webb et al. 2008). We applied (standard applicator, Style 49S; National Band and Tag Co., Newport, KY, USA) a uniquely numbered metal tag (Style 49, 3.65 × 0.95 cm; National Band and Tag Co.) in the lower half of the ear approximately 2 cm from the head. Deer received 2 metal tags, 1 in each ear (TAMUK IACUC protocols 2011-10-01 and 2014-09-29).

Data Analyses

Small plastic ear tags and Electronic Identification tags.—Captive deer were consistently monitored, so we knew when a deer lost its tag. To calculate tag retention, we divided the total number of tags that were lost by the total number of exposure years for each tag type (total no. of years that tags were in use). We calculated associated 95% confidence intervals (Zar 1984).

Large plastic ear tags and metal ear tags.—We used the nest survival model in Program MARK to estimate tag retention for the large plastic ear tags and metal ear tags (Rotella 2011). Although deer captures occurred continuously, not every free-ranging deer was recaptured every year, and not all deer were marked in the first year of study. We did not know the year that a tag was lost from deer that were not caught in consecutive years. The nest survival method is able to account for tags lost from these deer (Rotella 2011). We built a capture history for each tag to estimate tag retention. We assumed tag retention was constant across time, resulting in a single retention estimate for each tag type.

Ear tags can be ripped out during helicopter capture if they get caught on a net or nearby shrubs, which would increase tag loss estimates. We accounted for tags ripped out of ears during capture by considering them to have been present at the time of capture.

Passive Integrated Transponder tags.—We analyzed the ear PIT-tag data set and the leg PIT-tag data set separately using the nest survival model in Program MARK. We created 2 groups for the ear PIT-tag data set and the leg PIT-tag data set to test the influence of applicator experience on PIT tag retention. If Akaike Information Criterion (AIC_c) values of the constant model and group model were within 2 units (Anderson and Burnham 2002, Burnham and Anderson 2002), showing that there was support for both models, we used confidence intervals (CI) from the group model to assess differences in PIT tag retention between experienced and inexperienced applicators. We did not consider time in our model because we were interested in an average annual retention rate.

RESULTS

Small Plastic Ear Tags

We monitored 36 deer (21 M and 15 F) for 177 deer-years. Deer did not chew on ear tags as has been reported anecdotally in other captive deer facilities or research studies (Harper and Lightfoot 1966, Downing and McGinnes 1969). The annual retention rate was 0.978 (0.965–0.995; Table 1).

Electronic Identification Tags

We monitored EID tag retention for 401 deer at the Kerr WMA; 327 deer (538 deer-years) with button EID tags, and 74 deer (195 deer-years) with combi EID tags. Annual retention rates for the button and combi EID tags were 0.992 (0.983–0.998) and 0.979 (0.953–0.996; Table 1), respectively.

Large Plastic Ear Tags

We recaptured 832 male deer among the 5 study sites over the 11-year period. Fate of large plastic ear tags was known

Table 1. Annual retention rates for various tag types used on white-tailed deer in in Texas, USA, 1997–2007.

Tag type[a]	Tag placement	Tag sample size	Annual retention rate	95% CI	Duration of study	Captive vs. free-range deer
EID button	Right ear	329	0.992	0.983–0.998	2012–2015	Captive
EID combi	Right ear	74	0.979	0.953–0.996	2012–2015	Captive
Small plastic ear tag	Right ear	36	0.978	0.965–0.995	2004–2015	Captive
Large plastic ear tag	Right and left ears	2,665	0.958	0.950–0.965	1997–2007	Free-range
PIT tag	Base of ear	824	0.923	0.910–0.935	1997–2007	Free-range
Metal tag	Right and left ears	1,179	0.909	0.891–0.924	2011–2014	Free-range
PIT tag	Leg	813	0.779	0.758–0.800	1997–2007	Free-range

[a] EID, Electronic Identification; PIT, Passive Integrated Transponder.

for 2,665 tags. The status of large plastic tags in the left ear of 11 harvested deer was not reported and we removed these from our analysis. Annual retention rate for large plastic ear tags was 0.958 (0.950–0.965; Table 1). Seventeen of 832 deer (2.0%) lost both ear tags, but we were able to identify these deer by reading their PIT tags.

Passive Integrated Transponder Tags

Fate of PIT tags was known for 717 PIT tags implanted below the ear and 701 PIT tags implanted in the leg by nonexperienced personnel, and for 107 PIT tags implanted below the ear and 112 PIT tags implanted in the leg by experienced personnel. The AIC_c values for the group and constant models were within 2 units for the ear PIT tag (805.8 and 805.7, respectively) and leg PIT tag (1,351.9 and 1,352.4, respectively; Table 2). Using 95% CIs for PIT tags applied by inexperienced and experienced personnel for PIT tags at the base of the ear (0.903−0.932 vs. 0.905−0.970) and in the leg (0.753−0.798 vs. 0.734−0.848), we concluded there was no effect of experience in applying PIT tags. Thus, we report retention rates for the constant models. Annual retention rates for PIT tags placed below the ear and in the leg were 0.923 (0.910–0.935) and 0.779 (0.758−0.800; Table 1), respectively.

Metal Ear Tags

We recaptured 412 deer on the East Foundation ranches. Fifteen of the 412 recaptured deer (3.6%) appeared to have lost both tags. These deer were identified by tears in both ears that originated from where a metal tag would have been applied. Recaptured deer that appeared to have lost both ear tags were removed from the analysis because we were unable to identify the year that tags were applied. Annual retention rate for metal tags was 0.909 (0.891–0.924; Table 1).

DISCUSSION

Our results show that EID tags and small and large plastic ear tags had the greatest annual retention rates (>95%) for captive and free-range deer. Metal tags and PIT tags inserted below the ear had lower retention rates (<95%). Passive integrated transponder tags inserted in the leg had the lowest retention rates (78%). None of the tag types demonstrated 100% retention, which could lead to overestimates of population size and mortality for research of free-ranging deer (Nelson et al. 1980, Seber 1982). Tag failure could be particularly important for the captive cervid industry because unique identifiers are important for documenting breeding, movement, and herd health records. Although not addressed in our study, tattoos in the ear or lip or freeze-branding are other options for permanently or semipermanently marking animals (Silvy et al. 2012).

Our study design did not allow for direct comparison because tag retention in captive deer may be different from that in free-ranging deer. Differences in vegetative structure, fencing, and husbandry facilities could affect ear tag retention. For example, the few trees and shrubs in the captive facilities provide shade, but have little potential to snag ear tags, whereas dense brush in some areas of our study sites may have more potential to dislodge tags. The free-ranging deer in our study live in diverse habitats, with various vegetation types. Therefore, we believe the results from our free-ranging deer could be applicable to many different habitat types. Captive deer in our study were exposed to 2.5-m-tall net-wire fencing, but this fencing did not appear to influence retention of small plastic or EID tags because retention was high. Free-ranging deer were exposed to various fence types and tags could be ripped from

Table 2. Candidate models of white-tailed deer ear and leg Passive Integrated Transponder (PIT) tag retention in Texas, USA, 1997–2007. For each set of models, we provide number of parameters (K), second-order Akaike's Information Criterion (AIC_c), difference in AIC_c compared with the lowest AIC_c of the model set (Δ_i), AIC_c weight (w_i), and the 95% confidence interval for inexperienced and experienced taggers.

					95% CI	
Model	K	AIC_c	Δ_i	w_i	Inexperienced tagger	Experienced tagger
Ear PIT						
S(group)	22	805.808	0.086	0.489	0.903–0.932	0.905–0.970
S(.)	1	805.722	0.000	0.511		
Leg PIT						
S(group)	22	1,351.977	0.000	0.551	0.753–0.798	0.734–0.848
S(.)	1	1,352.393	0.416	0.448		

ears as deer run through or underneath net-wire or barbed wire fences.

The relatively low annual retention rate of metal ear tags used in this study could be due to several factors. Metal ear tags are applied using a special set of pliers that, when properly applied, cause the tag to lock closed (Silvy et al. 2012). However, if the tag is not locked closed, deer can be released with tags that eventually fall out. Thus, it is important to check the tags before releasing deer. Placement of the ear tag within the ear is another factor that may affect tag retention. If metal tags are not placed snug against the ear, the extra space could allow brush or other objects to rip the tag out of the ear (Silvy et al. 2012). Additional space may be left when tags are applied to fawns, allowing space for their ear to grow, but doing so could lower tag retention rate. Two-piece tags, such as plastic tags, are designed to be placed close to the head and close to the middle of the ear. Metal tags wrap around the ear, causing them to be placed close to the margin of the ear. Plastic tags may be more protected and less likely to be ripped out of the ear than metal tags.

Our results should only be applied to white-tailed deer or closely related cervid species. Although the tags types differ among past and present cervid studies, results are similar. In northwest Texas, plastic tag retention was 100% for 20 white-tailed deer and 95% for 15 mule deer over a 2-year period (Beasom and Burd 1983). Round aluminum ear tags had a 98.2% (109/111) retention rate for captive mule deer after 6 months (Harper and Lightfoot 1966) and a 94% (47/50) retention rate for 50 captive white-tailed deer fawns after 3.5 years (Downing and McGinnes 1969).

Our annual retention rate for PIT tags placed at the base of the ear (0.923) was similar to retention of PIT tags placed below the ear in bovine calves (0.938; Conill et al. 2000). Other studies found lower annual retention rates of PIT tags in cattle (0.730; Hasker et al. 1992) and veal calves (0.810; Lamboolj et al. 1999). A PIT tag in the leg may be more susceptible than a PIT tag at the base of the ear to blunt force that can crack the glass surrounding the transponder. An additional problem is that PIT tags may migrate from the point of injection, increasing the time necessary to scan for the tags (Silvy et al. 2012). Our results indicate that experience of personnel implanting PIT tags did not affect PIT tag retention. Conill et al. (2000) found similar results in a cattle operation, suggesting that PIT tag application is easy to learn. Brief, but thorough training on PIT tag insertion remains important (Conill et al. 2000).

If high tag retention is important, we recommend large or small plastic ear tags or EID ear tags for both captive and free-range deer. Users may consider using ≥ 2 tags of 1 type, or 2 different types, of tags for each animal to mitigate tag loss because no tag type in our study had perfect retention. Furthermore, choice of tag type will depend on constraints and objectives of marking animals. Passive integrated transponder tags are inconspicuous and may be desirable in herds where photography is an important activity, or useful for survival studies so as not to influence hunters' harvest decisions (Jacques et al. 2011). Conversely, visible tags, such as large plastic ear tags, are essential for mark–resight or behavioral studies. Cost of tags may affect how consumers and biologists decide on tag type. Passive integrated transponder tags and EID tags are more expensive than the metal or plastic ear tags. Electronic tags also require a scanner or reader, which increases initial cost. Although no single tag type demonstrated flawless retention, our results demonstrate variation in tag retention may influence management results and should be considered in cervid applications.

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