AN ANNOTATED BIBLIOGRAPHY OF BIRD MARKING TECHNIQUES[1]

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INTRODUCTION

A massive proliferation of bird marking techniques has occurred in recent decades as ornithologists have improved old methods or developed new methods to facilitate field investigations. Before beginning a bird marking study, an ornithologist has traditionally been faced with a review of voluminous literature available in various scattered journals and reports. Two decades ago, Cottam (1956) published an excellent review of bird marking techniques. More recently, Cogswell (1973) provided a worthwhile tabular summary of several color-marking methods currently being used, but his paper did not suggest advantages and disadvantages or list references for each technique. The present paper is an attempt to summarize, through 1975, the various techniques used on North American birds and the advantages or disadvantages of each technique. As with any similar undertaking, we have tried to examine the literature thoroughly and have probably overlooked a few important works. We apologize to those authors we have inadvertently neglected and would appreciate being informed of misinterpretations and omissions. Scientific names were taken from the American Ornithologists' Union Check-list (1957) and two recent supplements (*Auk*, **90**:411-419, 1973 and **93**:875-879, 1976).

Field recognition of birds has frequently been facilitated by attachment of various devices, alteration of the bird's appearance, or a combination of these. For a marker to be useful, it should meet most of the following criteria:

a. Involve no immediate or potential hindrance or irritation to the marked bird.

b. Be quick and easy to apply.

c. Have both readily visible and distinguishable digits and colors.

d. Give a reasonable promise of persisting on the bird long enough to reach research objectives.

e. Be relatively inexpensive.

f. Be easy to obtain or fabricate.

g. Produce no adverse affects on the behavior, longevity, or social life of the marked bird.

Very few marking techniques satisfy all of the above criteria, but the advantages and disadvantages of each technique should be considered before selecting an appropriate technique. Reports in the literature have stressed the disadvantages of each technique and, as a result, such a bias may be evident in this paper.

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[1]Contribution No. 357 of the Journal Series, Florida Agricultural Experiment Station, Gainesville, Florida 32611.

LEG MARKERS

Aluminum Bands

Undoubtedly the oldest and most widely used of all bird marking devices is the standard aluminum leg band or ring. Scientific banding began in Denmark in 1899, in the United States in 1902, and in Canada in 1905 (Cottam, 1956). Lincoln (1921) wrote an early account of the history and purposes of bird banding and later a manual for bird banders (Lincoln and Baldwin, 1929). Lists of species, A.O.U. numbers, and recommended leg band sizes are available in both Stamm (1967) and more recently from the Bird Banding Laboratory (Anonymous, 1976). Lockley and Russell (1953:20-31) also published useful suggestions for handling and marking birds. Size 3A and smaller aluminum bands are generally not suitable for field recognition of individuals since the number on the aluminum band cannot usually be seen at a distance; also, group recognition is hindered by the wide use of such bands. Thus, one major disadvantage of aluminum bands is that the birds must be recovered and rehandled.

Many other problems have been associated with the use of standard aluminum bands. Although Ludwig (1967) reported good durability of bands in salt water, excessive corrosion and wear in salt water has typified bands used on various shorebirds (Jehl, 1969), Manx Shearwaters (*Puffinus puffinus*) (Harris, 1964), and waterfowl (Lincoln, 1921). Corrosion due to defecation on their banded legs by Caspian Terns (*Sterna caspia*) has been noted by Ludwig (1967). Excessive band wear on Downy Woodpeckers (*Picoides pubescens*) also has been reported by Katholi (1970).

Ice build-up on legs of banded birds in cold climates has reportedly led to band loss, impairment of leg movement or leg loss in blackbirds (*Agelaius* sp.) (Elmes, 1955), chickadees (*Parus* sp.) (Dunbar, 1959), and American Goldfinches (*Carduelis tristis*) (MacDonald, 1961). Loss of bands has also been reported for Bald Eagles (*Haliaeetus leucocephalus*) (Berger and Mueller, 1960; Petersen, 1962), Great-horned Owls (*Bubo virginianus*) (Berger and Mueller, 1960), Herring Gulls (*Larus argentatus*) (Ludwig, 1967), and waterfowl (Martinson and Henny, 1967), although the principal causes of the losses were not identified.

Although most birds apparently adapt easily to being banded, leg irritation occasionally becomes a problem as reported for Rufous-sided Towhees (*Pipilo erythrophthalmus*) by Law (1929). An additional limitation of banding as a marking technique involves loss of bands from nestlings as discussed for Mourning Doves (*Zenaida macroura*) by Kaczynski and Kiel (1963). Behavioral aberrations resulting from banding include the removal of banded nestling Song Sparrows (*Melospiza melodia*) from the nest by their parents (Lovell, 1945), and repeated attempts by Cardinals (*Cardinalis cardinalis*) to remove bands from their legs (Young, 1941, Lovell, 1948).

Modified Aluminum Bands

Clearly corrosion, high losses, and wear of aluminum bands has been noted by many researchers. Band quality was decidedly inferior prior to about 1925 (Hickey, 1952) and Austin reported in 1947 that the bands he used on Common Terns (*Sterna hirundo*) were extremely soft, and it was necessary to reband the birds after only two years. Aluminum leg bands have been strengthened by the development of alloys, such as monel, and by improved manufacturing techniques. Retention of bands on young birds has been improved with band modifications for many species including Great Black-backed Gulls (*Larus marinus*) and Herring Gulls (Firth, 1971; Mills, 1972; Kadlec, 1975), ducklings (Leinish, 1963), and nestling Mourning Doves (Kossack, 1952; Peters, 1955). In cases where banding of young waterfowl has proven to be inadequate, web tagging has frequently been employed, even on unhatched ducklings still within their pipped eggs (Alliston, 1975).

Colored anodized aluminum leg bands have been employed to facilitate individual field recognition of Greater Prairie Chickens (*Tympanuchus cupido*) (Hammerstrom and Matteson, 1964), waterfowl (Balham and Elder, 1953), Ruffed Grouse (*Bonasa umbellus*) (Gullion et al., 1962; Gullion, 1965a; Godfrey, 1975), Rufous-sided Towhees (Childs, 1952), Chipping Sparrows (*Spizella passerina*), (Whittle, 1926), Gray Catbirds (*Dumetella carolinensis*), (Whittle, 1926), terns (Pessino, 1968), House Sparrows (*Passer domesticus*) (Cohen, 1969), Mockingbirds (*Mimus polyglottos*) (Hailman, 1960), Tufted Titmice (*Parus bicolor*) (Van Tyne, 1948), chickadees and White-breasted Nuthatches (*Sitta carolinensis*) (Butts, 1930). Several authors (Brackbill, 1951; McEntee, 1953; Reed, 1953) have cautioned that two or more metal bands on the same leg may cause the contacting edges of adjacent bands to flange and become harmful to the bird.

Plastic and Celluloid Leg Bands

Colored plastic and celluloid leg bands were developed to avoid some of the problems associated with colored aluminum bands. Colored plastic (SAFLAG, plexiglas, Vinylite, or PVC) leg bands with various modifications (Nagel, 1938; Wood, 1945; Phillips, 1955; Ellis, 1960) have been used with success on waterfowl (Sowls, 1950, 1955; Balham and Elder, 1953; MacKay, 1957; Martin, 1963; Ogilvie, 1972), various wildfowl (Kossack, 1951), Wild Turkeys (*Meleagris gallopavo*) (Ellis, 1960), Ruffed Grouse (Bendell and Fowle, 1950), gulls (Sargent, 1942; 1946; Poor, 1943; Woodbury and Knight, 1951; Poulding, 1951, 1954), herons (Phillips, 1955), Mexican Jays (*Aphelocoma ultramarina*) (Brown, 1963), Evening Grosbeaks (*Hesperiphona vespertina*) (Parks, 1953; Mason, 1956), California Thrashers (*Toxostoma redivivum*) (Sargent, 1940), Brown Towhees (*Pipilo fuscus*) (Michener and Michener, 1943), Northern Orioles (*Icterus galbula*) (Erickson, 1969), Wrentits (*Chamaea fasciata*) (Erickson, 1933), and Red-winged Blackbirds (Nero and Emlen, 1951). Colored leg bands have been useless for

marking hummingbirds (*Archilochus* sp.) (Stiles and Wolf, 1973) due to their small size and inconspicuous characteristic.

Colored Tape and Streamers

In addition to bands, various other materials have been attached to birds' legs to facilitate field recognition of individuals. Colored pressure-sensitive tape has been used as a marker (often over standard aluminum leg bands) to improve band retention and field recognition of birds. The major advantages of this method are that the marker is easy to apply, inexpensive, made of simple and available materials, adaptable to birds of different sizes, and may be rather long lasting (depending on how many layers of tape are applied). Kossack (1957) compared several of the readily available brands of tapes considering ease of application, durability, safety, and actual effectiveness in retaining adult bands on nestling Mourning Doves 4-8 days old. He concluded that Dalzoflex tape was the best tape available at that time. Colored tape has been used in marking many other species, including sparrows (Gullion, 1965b), blackbirds (Fankhauser, 1964), gulls (Fankhauser, 1964), Carolina Wrens (*Thryothorus ludovicianus*) (Ely, 1957), Tufted Titmice (Condee, 1968), and White-breasted Nuthatches (Ely, 1957).

Various modifications of leg tags or streamers have also been used to color-mark individual birds. Craighead and Stockstad (1956) used a falconer's jessed knot to fasten a plasticized PVC tape marker to birds. This method is apparently successful when notches are used to keep the jessed knot tightened on the bird's tarsus (Downing and Marshall, 1959). Several researchers (Campbell, 1960; Guarino, 1963; Thomas and Marburger, 1964; Frentress, 1975) have attached colored leg streamers using standard aluminum bands, but this technique has been criticized (Arnold and Coon, 1971) because it may cause friction and resultant wear on the bird's leg. Arnold and Coon (1971) successfully marked Brown-headed Cowbirds (*Molothrus ater*) and Great-tailed Grackles (*Quiscalus mexicanus*) with SAFLAG leg streamers and wing tags attached with No. 2 brass eyelets. These markers did not bind or restrict movement of the limbs. Similarly secured colored SAFLAG leg streamers were successfully used in a study of Chachalacas (*Ortalis vetula*), but attachment of SAFLAG wing tags inhibited flight in this species during preliminary testing and therefore were not used (Marion, 1974). Pop-rivets have also been used (Frentress, 1975) for fastening SAFLAG loops to standard aluminum leg bands.

Colored leg streamers, made of various materials, have been used with success on Wild Turkeys (Thomas and Marburger, 1964), gulls (Schreiber, 1965, 1968; Cuthbert and Southern, 1975); Sooty Terns (*Sterna fuscata*) (Smith, 1965), Starlings (*Sturnus vulgaris*) and blackbirds (Guarino, 1968), starlings and Crested Mynas (*Acridotheres cristatellus*) (Johnson, 1971); Loggerhead Shrikes (*Lanius ludovicianus*) (Lohrer, 1974); immature Mockingbirds (Kale and Jennings, 1966), and hummingbirds (Stiles and Wolf, 1973).

PLUMAGE COLORING AND MARKING

Another popular method of marking birds to facilitate field recognition involves the application of dyes and/or paints to the plumage. The main disadvantage of this technique is that the marker is short-lived, lasting at most only until the bird's next molt. In order for a dye to be a suitable marking agent, it should be nontoxic, wear and fade resistant, capable of being used with some type of wetting agent or solvent to insure quick penetration and even coverage, fast acting in a cool solution, and able to produce a readily distinguishable color change on a bird's plumage. Wadkins (1948) tested 14 dyes on penned Ring-necked Pheasants (*Phasianus colchicus*) and determined that Malachite green, brilliant green, Rhodamine B-extra, and purple batik were among the best. Additional information about dyes and methods have been summarized by Taber and Cowan (1969:315).

Dyes have been applied to captured birds of many species, including nestling Mockingbirds (Kale and Jennings, 1966), nestling American Robins (*Turdus migratorius*) (Schantz, 1939), various other passerines (Hester, 1963), Mourning Doves (Winston, 1954; Irby and Blankenship, 1966), Ring-necked Pheasants (Wadkins, 1948; Jones, 1950), Ruffed Grouse (Bendell and Fowle, 1950; Gullion et al., 1962; Godfrey, 1975), various waterfowl (Winston, 1955; Calif. Fish and Game, 1956), Herring Gulls (Gillespie, 1961), and Wandering Albatrosses (*Diomedea exulans*) (Tickell, 1968). Only Gillespie (1961) has reported behavioral changes in dyed birds (gulls).

Calif. Fish and Game (1956) personnel found it desirable to retain dyed waterfowl overnight to insure adequate drying of their wings. Others have attempted to minimize the trauma of handling birds by various "remote-dyeing" techniques: Mossman (1960) placed dye on eggs of brooding Glaucous-winged Gulls (*Larus glaucescens*) for transfer to the belly plumage of the nesting birds. Printer's ink and xylene in empty eggshells have been thrown at or near Ruffed Grouse (Bendell and Fowle, 1950), similarly dye-filled light bulbs were thrown at Sage Grouse (*Centrocercus urophasianus*) by Moffitt (1942), although he found buried, remotely-activated spray tanks to be much more effective.

Bendell and Fowle (1950) and Gullion et al. (1962) gained relocation data for Ruffed Grouse by recovery of dyed, molted feathers within a relatively small area. They found that Ruffed Grouse hens lost their feathers with the postnuptial molt, but juveniles dyed after the ages of about eight weeks retained a few dyed feathers for about one year. Ducklings have been successfully dyed by injection of dye into their eggs before hatching (Evans, 1951). Repeated plucking of rectrices of House Sparrows caused regrowth of feathers with a different natural color (Michener and Michener, 1932).

Dyed feathers have been glued or imped (Wright, 1939) to the upper surface of remiges and rectrices, with the latter generally giving the best results. This technique has been used on waterfowl (Low, 1945), Ring-necked Pheasants (Leopold et al., 1938;

Trippensee, 1941), Ruffed Grouse (Edminster, 1938; Bendell and Fowle, 1950), Tree Sparrows (*Spizella arborea*) (Heydweiller, 1934), Orchard Orioles (*Icterus spurius*), Gray Catbirds, and Indigo Buntings (*Passerina cyanea*) (Neal, 1964; Work, 1964). In some instances (Low, 1945; Goforth and Baskett, 1965) dyed feathers have been glued to the head of the bird. This method apparently works over short time intervals, but dyed feathers fade within five or six months of application and are lost during the annual molt. Yellow feathers attached to the heads of Mourning Doves (Goforth and Baskett, 1965) disrupted pair bonds, whereas backtags (discussed later) did not.

Hester (1963) found feather imping to be unsatisfactory for passerines because it is time consuming, allows few color combinations, and the marker is not highly visible on these small birds. This method is generally useful only for a short-term study due to the annual molt. Feather imping was tried for waterfowl at Delta, Manitoba (Sowls, 1950) and abandoned as less satisfactory than painting feathers with airplane dope.

Paints (or airplane dopes) have been used with some success for marking primaries and rectrices of various species. As with dyes, this method is best suited to short-term nesting studies so that the loss of marked plumage during the postnuptial molt is insignificant. Paints have been applied to various parts of hummingbirds (Stiles and Wolf, 1973), Barn (*Hirundo rustica*) and Cliff swallows (*Petrochelidon pyrrhonota*) (Samuel, 1970); chickadees (Butts, 1930; Kennard, 1961), White-breasted Nuthatches (Butts, 1930), Mourning Doves (Swank, 1952; Frankel and Baskett, 1963; Goforth and Baskett, 1965), Ring-necked Pheasants (Kozicky and Weston, 1952), waterfowl (Sowls, 1950, 1955), Black-footed Albatrosses (*Diomedea nigripes*) (Miller, 1940, 1942), and Bald Eagles (Petersen, 1962). The only behavioral change reported was pair bond disruption in Mourning Doves with painted heads (Frankel and Baskett, 1963).

Swank (1952) concluded that distinct, solid lines painted on the outer wing feathers of Mourning Doves were better markers than painted numbers or letters. Kozicky and Weston (1952) reported better retention of paint on rectrices of Ring-necked Pheasants after prior application of household cement.

Other miscellaneous techniques have been employed to change the external appearance of birds, such as stapling a colored plastic tag to the dorsal surface of the tail feathers of Ring-necked Pheasants (Trippensee, 1941), distributing metal dust in dust baths which is visible upon close examination of molted or lost feathers (Bendell and Fowle, 1950), freeze-branding ducklings (Greenwood, 1975), tatooing of starling chicks (Ricklefs, 1973), transplanting the alular feathers from the wing to head of experimental gulls, Bobwhite (*Colinus virginianus*), and Starlings (Coppinger and Wentworth, 1966), removing the alular feathers to distinguish game farm-reared from wild Mallards (*Anas platyrhynchos*) (Burger et al., 1970), and notching a "V" in the rectrices of Ruffed Grouse (Edminster, 1938). Edminster (1938) also distinctively "sound-marked" these grouse by attaching cat bells to their wings.

BACKTAGS

In an attempt to overcome some of the disadvantages of plumage dyes and paints (loss of marker due to molting or fading, few color combinations), investigators have used backtags (or saddle harnesses) for marking birds. Blank and Ash (1956) first published a description of a backtag they used for Gray Partridge (*Perdix perdix*) in England, which consisted of a lettered and/or numbered plastic tab lying flat on the bird's back and held in position by means of a soft leather harness. They reported that while the plastic tab will last at least two years, the leather harness deteriorates and breaks after about 15 months on the bird.

Labisky and Mann (1962) tested the durability of five different plastic materials used as backtags for Ring-necked Pheasants and found backtags constructed of U.S. Fiberthin and Armor Tite (both vinyl-coated nylon-mesh materials) with good quality leather or Fiberthin straps to have the potential of being durable markers for several years of use. Backtags have also been used with success on Mourning Doves (Frankel and Baskett, 1963), Bobwhite, Mallards, Bald Eagles (Southern, 1964), and Red Grouse (*Lagopus lagopus*) (Boag et al., 1973). Backtag markers modified into "ponchos" have been used successfully on Sage Grouse, Sharp-tailed Grouse (*Pedioecetes phasianellus*), and Hungarian Partridge (*Perdix perdix*) (Pyrah, 1970). Data from a six-year study of the Ruffed Grouse in Minnesota (Gullion et al., 1962) indicate that back-tagging (as compared to color banding) apparently increases vulnerability to avian predation with a very significant shortening of survival of back-tagged grouse.

Average retention time for backtags with buckskin leather harnesses on Ruffed Grouse was 6.5 months, with a maximum of 33 months (Gullion et al., 1962). The average retention time for backtags on six Common Gallinules (*Gallinula chloropus*) was 12 months (Anderson, 1963). Backtag use on gallinules was discontinued because the leather harness became brittle and eventually broke, causing discomfort and danger to the bird. Backtags have also been inadequate for marking smaller birds, such as Starlings (Hester, 1963). The major problems were (1) difficulty in attaching them properly to small birds, (2) interference with flight if tags are large enough to have numbers painted on them, and (3) excessive consumption of time when working with many birds. Backtags have, therefore, been used with more success on larger birds (particularly gallinaceous game birds) than on smaller birds.

NECKBANDS OR COLLARS

Plastic neckbands or collars have been used extensively for marking waterfowl, primarily Canada Geese (*Branta canadensis*) and Brant, (*Branta bernicla*) (Steenis, 1952; Helm, 1955; Barry, 1956; Craighead and Stockstad, 1956; MacInnes, 1961; Ballou and Martin, 1964; Sherwood, 1966; MacInnes et al., 1969; Fjetland, 1973; Koerner et al., 1974). Aldrich and Steenis (1955) summarized some of the advantages and disadvantages of neck banding and other color marking of waterfowl, and concluded that properly

applied neck bands are extremely good markers for Canada Geese. Colored, rigid plastic collars are highly visible, inexpensive, and have no adverse effect on behavior of geese (Ballou and Martin, 1964). Flexible plastic collars have several advantages over rigid plastic collars since flexible collars are lighter and easier to apply than rigid collars and do not shatter when hit by lead shot. Flexible plastic collars proved to be far more satisfactory than nasal discs (discussed later) placed on Canada Geese at Seney National Wildlife Refuge in Michigan (Sherwood, 1966).

Minor disadvantages of plastic neckbands are: application of durable code symbols to plastic bases are difficult and time-consuming, materials are not fade-resistant, and plexiglas collars cannot be attached quickly in the field. MacInnes et al. (1969) alleviated several disadvantages of most plastic neckbands by developing an aluminum collar for geese which was colored and lettered with plastic film tape. These modified aluminum collars were slightly more expensive than the plastic ones, but the colored tape on the aluminum collars was both durable and available in many color combinations.

Reports on the success of neckbands have not all been favorable. Lensink (1968) reported that neckbands inhibited reproduction in Black Brant. It has also been recently suggested (Ankney, 1975) and debated (Raveling, 1976) that aluminum neckbands have contributed to starvation in female Lesser Snow Geese (*Chen caerulescens*).

Several trials with neckbands or collars on ducks have resulted in failure. According to Helm (1955), no matter how tight the collar was placed around the duck's neck, its bill would soon get caught in the collar in an effort to dislodge it. Therefore, the use of neckbands and collars seems to be more promising for geese than for smaller waterfowl. Colored neck collars have also been successfully used on Whistling Swans (*Olor columbianus*) (Sladen and Cochran, 1969; Sladen, 1972, 1973), Sandhill Cranes (*Grus canadensis*) (Huey, 1965), and even House Sparrows (North, 1969).

COLORED NECK TAGS

Few studies have involved the use of colored neck tags to mark birds, mainly because they involve potential injury to the bird. Taber (1949) attached two colored Koroseal tags to a silver-plated surgical safety pin that was inserted through a small pinch of loose skin at the posterior base of the neck of Ring-necked Pheasants. These markers reportedly have an advantage over colored leg bands because these neck tags are readily identifiable from a distance in many dense vegetation situations (Collias and Taber, 1951). However, retention was poor on neck-tagged pheasants (Nelson, 1955). Neck tags have also been tried on Wild Turkeys (Ellis, 1960), American Woodcock (*Philohela minor*) (Westfall and Weeden, 1956), Gambel's Quail (*Lophortyx gambelii*) (Gullion, 1962), American Coots (*Fulica americana*) (Gullion, 1951), and Canada Geese (Helm, 1955).

The neck tags on Canada Geese were quickly torn off by the marked birds or by other geese, resulting in very poor retention

times. Neck tags similar to those described here have not been used extensively in recent years primarily because of the main disadvantages of this marking technique, namely poor retention and possible irritation or injury to the bird.

PATAGIAL (WING) MARKERS

Patagial tags have generally been made of plasticized nylon fabric attached by various methods to the dorsal surface of each wing. These tags have been used with success on waterfowl (Anderson, 1963; Jones and Leopold, 1967; Havlin, 1968; Weeks, 1972), Wild Turkeys (Knowlton et al., 1964; Ellis and Lewis, 1967), Brown Pelicans (*Pelecanus occidentalis*) (Schreiber and Williams, 1973), Red Grouse (Boag et al., 1975), gulls (Southern, 1971), and passerines (Hester, 1963; Hewitt and Austin-Smith, 1966; Mathisen, 1966).

A major advantage of patagial tags is that the markers are generally much more conspicuous than leg markers or back tags which frequently become obscured by long contour feathers on the bird's back. Knowlton et al. (1964) and Ellis and Lewis (1967) reported excellent visibility and retention of patagial tags used on Wild Turkeys. Anderson (1963) used patagial tags as markers for waterfowl because they are exposed to abrasion less than leg bands and are retained well for several seasons. He reported that behavior after tagging was normal in gallinules, Mallards, and Black-headed Gulls (*Larus ridibundus*), but eiders (*Somateria* sp.) showed an adverse behavioral reaction to the presence of the tags.

Modified patagial tags have been developed for use on smaller passerines to minimize any potential hazards. Hester (1963) used a No. 3 poultry wing band to attach the tags to the patagium of robins, Starlings, Blue Jays (*Cyanocitta cristata*), and Common Grackles (*Quiscalus quiscula*). Hewitt and Austin-Smith (1966) further modified the patagial tag so that it could be fastened around the base of the humerus. Results of these and other studies indicate that patagial markers are generally reliable and adaptable to many avian species.

NASAL DISCS AND SADDLES

Numbered nasal discs such as those described by Bartonek and Dane (1964) have been used in studies involving large numbers of individually marked waterfowl. These are usually 5/8-inch or 3/4-inch discs, one on each side of the bird's bill, which are connected by a nylon monofilament or silver wire passing through the nasal opening. Bartonek and Dane (1964) reported that these nasal discs were durable and offered many possible combinations, but were time consuming to make. Sherwood (1966) reported two disadvantages of nasal discs used on Canada Geese: retention rates were very low (20% for 1 year, 0% for two years), and geese were often injured (ripped nares) by discs when they were recaptured in nets. As a result, Sherwood (1966) recommended the use of flexible plastic collars on geese rather than nasal discs.

Higher mortality rates among mergansers (*Mergus* sp.) and other diving ducks have been attributed to entanglement of nasal discs in submerged vegetation (Sugden and Poston, 1968). To overcome this problem, these investigators developed a nasal saddle of colored plasticized polyvinyl chloride tape for marking ducks. This tape was fastened to the bill with a piece of nylon threaded through the nares, thus eliminating the projecting discs which frequently catch on submerged vegetation and fishing line. Nasal saddles are generally easy to make, retained well, and readily seen on ducks; however, they are time consuming to apply and do not provide a wide range of color combinations (Sugden and Poston, 1968). Recent improvements in methods of attachment (e.g. curved stainless steel pins and washers) and in possible number of combinations (e.g. by adding black numerals) have made nasal saddles even more effective as markers for waterfowl (Doty and Greenwood, 1974; Alison, 1975).

RADIO (BIO-) TELEMETRY

Biotelemetry has been described as the instrumental technique for gaining and transmitting information from a living organism and its environment to a remote observer (Adams, 1965a). Dr. Galler (*in* Adams, 1965a) also referred to biotelemetry in the mid-1960's as "the new status symbol of the biologist." Many ecological parameters, including location, temperature, pressure, humidity, heart rate, respiration rate, blood pressure, electrocardiogram, etc. have been measured by the use of telemetry (Adams and Smith, 1964). Biotelemetry has been used extensively in field studies involving movements, home ranges (Godfrey, 1975), and navigation (Southern, 1965a) of birds of various sizes. Activities of shy or difficult-to-handle animals can be conveniently monitored through biotelemetry without the necessity of repeated resightings and/or handling.

The Wildlife Telemetry Newsletter and various national and international references have made biotelemetry information available to a large number of field investigators. Several bibliographies and better sources of this information are Slater (1963), Cochran and Lord (1963), Southern (1965b), Adams (1965a, 1965b), Cochran et al. (1965), and Barwick and Fullagar (1967). The paper by Adams (1965a) is particularly useful because it provides a chart listing species, investigator, types of data sought, and specifications for transmitters, receivers, antennas, and batteries used for various avian species.

As with previous marking techniques, there have been numerous modifications and innovations (Kuechle, 1967; Brander, 1968; Nicholls and Warner, 1968; Bray and Corner, 1972; Dunstan, 1972, 1973; Dwyer, 1972) in the hardware involved with radio telemetry. In most cases, equipment used has been the result of a desired combination of weight, power, and desired life of transmitters in the field. Kuck (1966) designed an improved battery pack for use on pheasants, and Patton et al. (1973) published a detailed description of the use of solar panels as energy sources

for radio transmitters. Antennas of various shapes (mostly linear or loops) and sizes (Kolz and Corner, 1975) have also been employed depending on animal size, habitat, and desired range of signal transmission. Generally, the higher the receiving antenna above the ground, the greater the reception; as a result, various elevating and rotating mechanisms have been developed for mobile receiving units (Bray et al., 1975; Kolz and Johnson, 1975). The best reception for larger animals and birds is generally from fixed-wing aircraft, and Hoskinson has recently (1976) described the effect of different pilots on radio telemetry results.

Radio telemetry has been employed in studies of the behavior of owls (Nicholls and Warner, 1968, 1972; Dunstan, 1973; Forbes and Warner, 1974), hawks (Southern, 1965a; Dunstan, 1973), Bald Eagles (Southern, 1964, 1965a, 1965b), gulls (Southern, 1964, 1965a, 1965b), Ruffed Grouse (Gullion et al., 1962; Marshall and Kupa, 1963; Marshall, 1965; Patton et al., 1968; Huempfner, 1975), Sage Grouse (Wallestad, 1971), Sharp-tailed Grouse (McEwan and Brown, 1966), Spruce Grouse (*Canachites canadensis*) (Ellison, 1974), Red Grouse (Boag, 1972), turkeys (Patton et al., 1968), Ring-necked Pheasants (Hessler et al., 1970), Bobwhite (Southern, 1965a, 1965b), Gray Partridge (Southern, 1965a), and woodcock (Godfrey, 1970; Ramakka, 1972; Dunford and Owen 1973; Owen and Morgan, 1975).

Additional work involving radio telemetry includes studies on ducks (Southern, 1965a; Gilmer et al., 1971; Dwyer, 1972; Greenwood and Sargeant, 1973; Gilmer et al., 1974, 1975; Ball et al., 1975), pigeons (*Columba* sp.,) (Anonymous, 1961; Singer *in* Slater, 1963); Purple Martins (*Progne subis*) (Southern, 1965a), robins, House Sparrows, Common Grackles (Graber and Wunderle, 1966), thrushes (*Catharus* sp.) (Cochran et al., 1967), and Starlings (Graber and Wunderle, 1966; Bray et al., 1975).

Major advantages to biotelemetry frequently cited in the above investigations were that (a) continuous monitoring is possible for the length of transmitter battery life, (b) a minimum of trapping and handling is necessary to identify individual birds in the field, and (c) this is probably the only adequate way to monitor movements (by airplane or perhaps satellite) of highly mobile avian species. Frequently mentioned disadvantages of avian biotelemetry include (a) problems with attachment of transmitters and their retention, (b) occasional skin abrasion or irritation due to the harness (or other attachment device) on the bird, (c) much effort and equipment are necessary for long distance tracking studies, and (d) possible weight loss or alteration of behavior and/or activity, particularly during the first few weeks after attachment of the transmitter. Also, susceptibility to predation frequently increases as a result of altered behavior or activity patterns.

Common limitations of biotelemetry studies are on total allowable weight, range of transmitter signal, and battery life. Miniaturization and improvements in both transmitters and battery packs in the last decade have contributed substantially to reducing these limitations on avian biotelemetry studies.

SUMMARY

Many bird marking techniques have been developed in North America since the early 1900's as avian studies have become more sophisticated. Depending upon the research objectives and budget, ornithologists now have a wide array of marking techniques and/or devices available to them, including various leg bands and streamers, plumage markers, back tags, neckbands or collars, neck tags, patagial tags, nasal discs or saddles, and biotelemetry. Leg bands have been widely used in combination with the other marking techniques, since leg bands alone are not generally suitable for individual field recognition of birds. Colored leg bands, tape and streamers have been used successfully on many species to improve this field recognition. Plumage coloring has also been used for this, but it lasts only until the bird's next molt.

Back tags have been popular markers for gallinaceous game birds due to good retention and many possible color combinations, but have not been used extensively on smaller birds. Neckbands or collars generally work well on geese, swans, and Sandhill Cranes, but not on smaller waterfowl. Flexible collars have been found to work better than rigid plastic collars, but colored neck tags are generally not regarded as good markers for waterfowl or game birds. Patagial tags have proven generally reliable and adaptable for many birds of various sizes and are more conspicuous than back tags. Nasal saddles are apparently better than nasal discs for marking ducks, although flexible collars are better markers for geese than nasal saddles. Biotelemetry is the most recent and sophisticated of the marking devices discussed in this paper. In addition to providing a marker for individual recognition, biotelemetry provides a useful and versatile tool for monitoring a variety of avian activities and environmental conditions.

Any investigators who are inexperienced in bird marking are urged to take full advantage of this compilation by referring to the appropriate studies included in this paper. The conclusions and advice of previous researchers may both minimize unrewarded effort and increase the prospects for reliable results.

LITERATURE CITED

ADAMS, L. 1965a. Progress in ecological biotelemetry. *BioScience*, **15**: 83-86.

———. 1965b. Bibliography - biotelemetry. *BioScience*, **15**: 155-157.

ADAMS, L., AND W. C. SMITH. 1964. Wildlife telemetry. Proc. Natl. Telemetering Conf., 2-3: 1-7.

ALDRICH, J. W., AND J. H. STEENIS. 1955. Neck banding and other colormarking of waterfowl; its merits and shortcomings. *J. Wildl. Manage.*, **19**: 317-318.

ALISON, R. M. 1975. Capturing and marking oldsquaws. *Bird-Banding*, **46**: 248-250.

ALLISTON, W. G. 1975. Web-tagging ducklings in pipped eggs. *J. Wildl. Manage.*, **39**: 625-628.

AMERICAN ORNITHOLOGISTS' UNION. 1957. Check-list of North American birds, fifth ed. Baltimore, Md., Amer. Ornithol. Union.

ANDERSON, A. 1963. Patagial tags for waterfowl. *J. Wildl. Manage.*, **27**: 284-288.

ANKNEY, C. D. 1975. Neck bands contribute to starvation in female lesser snow geese. *J. Wildl. Manage.*, **39**: 825-826.

ANONYMOUS. 1961. To probe pigeon mystery. *Science Newsletter,* **79:** 359.

———. 1976. North American Bird Banding Manual. U.S. Fish and Wildlife Service.

ARNOLD, K. A., AND D. W. Coon. 1971. A technique modification for color-marking birds. *Bird-Banding,* **42:** 49-50.

AUSTIN, O. L., JR. 1947. A study of the mating of the Common Tern (*Sterna h. hirundo*). *Bird-Banding,* **18:** 1-16.

BALHAM, R. W., AND W. H. ELDER. 1953. Colored leg bands for waterfowl. *J. Wildl. Manage.,* **17:** 446-449.

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

BALLOU, R. M., AND F. W. MARTIN. 1964. Rigid plastic collars for marking geese. *J. Wildl. Manage.,* **28:** 846-847.

BARRY, T. W. 1956. Brant with yellow neck bands. *Eastern Bird Banding Assoc. News,* **19:** 60.

BARTONEK, J. C., AND C. W. DANE. 1964. Numbered nasal discs for waterfowl. *J. Wildl. Manage.,* **28:** 688-692.

BARWICK, R. E., AND P. J. FULLAGAR. 1967. A bibliography of radio telemetry in biological studies. *Proc. Ecol. Soc. Aust.,* **2:** 27-49.

BENDELL, J. F. S., AND C. D. FOWLE. 1950. Some methods for trapping and marking Ruffed grouse. *J. Wildl. Manage.,* **14:** 480-482.

BERGER, D. D., AND H. C. MUELLER. 1960. Band retention. *Bird-Banding'* **31:** 90-91.

BLANK, T. H., AND J. S. ASH. 1956. Marker for game birds. *J. Wildl. Manage.,* **20:** 328-330.

BOAG, D. A. 1972. Effect of radio packages on behavior of captive red grouse. *J. Wildl. Manage.,* **36:** 511-518.

BOAG, D. A., A. WATSON, AND R. PARR. 1973. Radio-marking vs. back-tabbing Red Grouse. *J. Wildl. Manage.,* **37:** 410-412.

———., ———., AND ———. 1975. Patagial streamers as markers for Red Grouse chicks. *Bird-Banding,* **46:** 248.

BRACKBILL, H. 1951. Colored bands. *Eastern Bird Banding Assoc. News,* **14:** 5-6.

BRANDER, R. B. 1968. A radio-package harness for game birds. *J. Wildl. Manage.,* **32:** 630-632.

BRAY, O. E., AND G. W. CORNER. 1972. A tail clip for attaching transmitters to birds. *J, Wildl. Manage.,* **36:** 640-642.

BRAY, O. E., K. H. LARSEN, AND D. F. MOTT. 1975. Winter movements and activities of radio-equipped Starlings. *J. Wildl. Manage.,* **38:** 795-801.

BRAY, O. E., R. E. JOHNSON, AND A. L. KOLZ. 1975. A removable car-top antenna system for radio-tracking birds. *Bird-Banding,* **46:** 15-18.

BROWN, J. L. 1963. Social organization and behavior of the Mexican Jay. *Condor,* **65:** 126-153.

BURGER, G. V., R. J. GREENWOOD, AND R. C. OLDENBURG. 1970. Alula removal technique for identifying wings of released waterfowl. *J. Wildl. Manage.,* **34:** 137-140.

BUTTS, W. K. 1930. A study of the chickadee and White-breasted Nuthatch by means of marked individuals. *Bird-Banding,* **1:** 149-168.

CALIFORNIA FISH AND GAME DEPARTMENT. 1956. Color marking of white geese. *Western Bird Banding Assoc. News,* **31:** 7-8.

CAMPBELL, D. L. 1960. A colored leg strip for marking birds. *J. Wildl. Manage.,* **24:** 431.

CHILDS, H. E., JR. 1952. Color bands. *Western Bird Banding Assoc. News,* **27:** 4.

COCHRAN, W. W., AND R. D. LORD, JR. 1963. A radio-tracking system for wild animals. *J. Wildl. Manage.,* **27:** 9-24.

COCHRAN, W. W., D. W. WARNER, J. R. TESTER, AND V. B. KUECHLE. 1965. Automatic radio-tracking system for monitoring animal movements. *BioScience*, **15**: 98-100.

COCHRAN, W. W., G. G. MONTGOMERY, AND R. R. GRABER. 1967. Migratory flights of *Hylocichla* thrushes in spring: a radiotelemetry study. *Living Bird*, **6**: 213-225.

COGSWELL, H. L. 1973. Tabular summary and annotation of color-marking methods exhibited by W.B.B.A. at the Sept. 1971 meeting of the A.O.U. in Seattle. *Western Bird Bander*, **48**: 5-9.

COHEN, R. 1969. Color-banded House Finches. *Eastern Bird Banding Assoc. News*, **32**: 81-82.

COLLIAS, N. E., AND R. D. TABER. 1951. A field study of some grouping and dominance relations in Ring-necked Pheasants. *Condor*, **53**: 265-275.

CONDEE, R. W. 1968. Color-banding small passerines. *Inland Bird Banding Assoc. News*, **40**: 219.

COPPINGER, R. P., AND B. C. WENTWORTH. 1966. Identification of experimental birds with the aid of feather autografts. *Bird-Banding*, **37**: 203-205.

COTTAM, C. 1956. Uses of marking animals in ecological studies: marking birds for scientific purposes. *Ecology*, **37**: 675-681.

CRAIGHEAD, J. J., AND D. S. STOCKSTAD. 1956. A colored neckband for marking birds. *J. Wildl. Manage.* **20**: 331-332.

CUTHBERT, F. J., AND W. E. SOUTHERN. 1975. A method for marking young gulls for individual identification. *Bird-Banding*, **46**: 252-253.

DOTY, H. A., AND R. J. GREENWOOD. 1974. Improved nasal-saddle marker for Mallards. *J. Wildl. Manage.*, **38**: 938-939.

DOWNING, R. L., AND C. M. MARSHALL. 1959. A new plastic tape marker for birds and mammals. *J. Wildl. Manage.*, **23**: 223-224.

DUNBAR, I. K. 1959. Leg bands in cold climates. *Eastern Bird Banding News*, **22**: 37.

DUNFORD, R. D., AND R. B. OWEN, JR. 1973. Summer behavior of immature radio-equipped woodcock in central Maine. *J. Wildl. Manage.*, **37**: 462-469.

DUNSTAN, T. C. 1972. A harness for radio-tagging raptorial birds. *Inland Bird Banding News*, **44**: 4-8.

———. 1973. A tail feather package for radio-tagging raptorial birds. *Inland Bird Banding News*, **45**: 6-10.

DWYER, T. J. 1972. An adjustable radio-package for ducks. *Bird-Banding*, **43**: 282-284.

EDMINSTER, F. 1938. The marking of Ruffed Grouse for field identification. *J. Wildl. Manage.*, **2**: 55-57.

ELLIS, R. J. 1960. Trapping and marking Rio Grande Wild Turkeys. *Proc. Oklahoma Acad. Sci.* **41**: 202-212.

ELLIS, J. E., AND J. B. LEWIS. 1967. Mobility and annual range of Wild Turkeys in Missouri. *J. Wildl. Manage.*, **31**: 568-581.

ELLISON, L. N. 1974. Population characteristics of Alaskan Spruce Grouse. *J. Wildl. Manage.*, **38**: 383-395.

ELMES, R. 1955. Loss of rings. *Bird Study*, **2**: 153.

ELY, G. P. 1957. Color banding. *Eastern Bird Banding Assoc. News*, **20**: 59.

ERICKSON, M. M. 1933. Thoughts on the use of colored bands. *Western Bird Banding Assoc. News*, **8**: 9-10.

ERICKSON, J. E. 1969. Banding studies of wintering Baltimore Orioles in North Carolina, 1963- 66. *Bird-Banding*, **40**: 181-198.

EVANS, C. D. 1951. A method of color-marking young waterfowl. *J. Wildl. Manage.*, **15**: 101-103.

FANKHAUSER, D. 1964. Plastic adhesive tape for color-marking birds. *J. Wildl. Manage.*, **28**: 594.

FIRTH, R., JR. 1971. A technique for banding nestling gull chicks. *Bird-Banding*, **42**: 301.

FJETLAND, C. A. 1973. Long-term retention of plastic collars on Canada geese. *J. Wildl. Manage.*, **37**: 176-178.

FORBES, J. E., AND D. W. WARNER. 1974. Behavior of a radio-tagged Saw-whet owl. *Auk*, **91**: 783-795.

FRANKEL, A. I., AND T. S. BASKETT. 1963. Color-marking disrupts pair bonds of captive Mourning Doves. *J. Wildl. Manage.*, **27**: 124-127.

FRENTRESS, C. 1975. Pop-rivet fasteners for color markers. *Inland Bird Banding Assoc. News*, **47**: 3-9.

GILLESPIE, M. 1961. Herring Gulls at Martha's Vineyard. *Eastern Bird Banding Assoc. News*, **24**: 136-137.

GILMER, D. S., V. B. KUECHLE, AND I. J. BALL, JR. 1971. A device for monitoring radio-marked animals. *J. Wildl. Manage.*, **35**: 829-832.

GILMER, D. S., I. J. BALL, L. M. COWARDIN, AND J. H. REICHMANN. 1974. Effects of radio packages on wild ducks. *J. Wildl. Manage.*, **38**: 243-252.

GILMER, D. S., I. J. BALL, L. M. COWARDIN, J. H. REICHMANN, AND J. R. TESTER. 1975. Habitat use and home range of mallards breeding in Minnesota. *J. Wildl. Manage.*, **39**: 781-789.

GODFREY, G. A. 1970. A transmitter harness for small birds. *Inland Bird Banding Assoc. News*, **42**: 3-5.

———. 1975. Home range characteristics of Ruffed Grouse broods in Minnesota. *J. Wildl. Manage.*, **39**: 287-298.

GOFORTH, W. R., AND T. S. BASKETT. 1965. Effects of experimental color marking on pairing of captive Mourning Doves. *J. Wildl. Manage.*, **29**: 543-553.

GRABER, R. R., AND S. L. WUNDERLE. 1966. Telemetric observations of a Robin (*Turdus migratorius*). *Auk*, **83**: 674-677.

GREENWOOD, R. J. 1975. An attempt to freeze-brand mallard ducklings. *Bird-Banding*, **46**: 204-206.

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.

GUARINO, J. L. 1963. Blackbird and Starling movements traced by banding and color-marking. *Inland Bird Banding Assoc. News.*, **35**: 65.

———. 1968. Evaluation of a colored leg tag for Starlings and blackbirds. *Bird-Banding*, **39**: 6-13.

GULLION, G. W. 1951. A marker for waterfowl. *J. Wildl. Manage.*, **15**: 222-223.

———. 1962. Organization and movements of coveys of a Gambel Quail population. *Condor*, **64**: 402-415.

———. 1965a. Improvements in methods for trapping and marking Ruffed Grouse. *J. Wildl. Manage.*, **29**: 109-116.

———. 1965b. Another comment on the color-banding of birds. *J. Wildl. Manage.*, **29**: 401.

GULLION, G. W., R. L. ENG, AND J. J. KUPA. 1962. Three methods for individually marking Ruffed Grouse. *J. Wildl. Manage.*, **26**: 404-407.

HAILMAN, J. P. 1960. Hostile dancing and fall territory of a color-banded Mockingbird. *Condor*, **62**: 464-468.

HAMERSTROM, F. N., JR, AND O. E. MATTESON. 1964. A numbered, metal color-band for game birds. *J. Wildl. Manage*, **28**: 850-852.

HARRIS, M. P. 1964. Ring loss and wear of rings on marked Manx Shearwaters. *Bird Study*, **10**: 39-46.

HAVLIN, J. 1968. Wing-tagging ducklings in pipped eggs. *J. Wildl. Manage.*, **32**: 172-174.

HELM, L. G. 1955. Plastic collars for marking geese. *J. Wildl. Manage.*, **19**: **19**: 316-317.

HESSLER, E., J. R. TESTER, D. B. SINIFF, AND M. M. NELSON. 1970. A biotelemetry study of survival of pen-reared pheasants released in selected habitats. *J. Wildl. Manage.*, **3** : 267-274.

HESTER, A. E. 1963. A plastic wing tag for individual identification of passerine birds. *Bird-Banding*, **34**: 213-217.

HEWITT, O. H., AND P. J. AUSTIN-SMITH. 1966. A simple wing tag for field marking birds. *J. Wildl. Manage.*, **30**: 625-627.

HEYDWEILLER, M. A. 1934. Tail plumes as a means of marking individual birds. *Bird-Banding*, **5**: 45-47.

HICKEY, J. J. 1952. Survival studies of banded birds. U.S. Fish and Wildl. Serv. Spec. Sci. Rep. No. 15.

HOSKINSON, T. L. 1976. The effect of different pilots on aerial telemetry error. *J. Wildl. Manage.*, **40**: 137-139.

HUEMPFNER, R. A. 1975. Recapturing radio-tagged Ruffed Grouse by night-lighting and snow-burrow netting. *J. Wildl. Manage.*, **39**: 821-823.

HUEY, W. S. 1965. Sight records of color-marked Sandhill Cranes. *Auk*, **83**: 640-643.

IRBY, H. D., AND L. H. BLANKENSHIP. 1966. Breeding behavior of immature Mourning Doves. *J. Wildl. Manage.*, **30**: 598-604.

JEHL, Jr. 1969. Band wear in stilt sandpipers — a warning. *Bird-Banding*, **40**: 47.

JOHNSON, S. R. 1971. A colored leg tag for nestling and adult birds. *Bird-Banding*, **42**: 129-131.

JONES, G. F. 1950. Observations of color-dyed pheasants. *J. Wildl. Manage.*, **14**: 81-83.

JONES, R. E., AND A. S. LEOPOLD. 1967. Nesting interference in a dense population of Wood Ducks. *J. Wildl. Manage.*, **31**: 221-228.

KACZYNSKI, C. F., AND W. H. KIEL, JR. 1963. Band loss by nestling Mourning Doves. *J. Wildl. Manage.*, **27**: 271-279.

KADLEC, J. A. 1975. Recovery rates and loss of Al, Ti, and Incoloy bands on Herring gulls. *Bird-Banding*, **46**: 230-235.

KALE, H. W., III, AND W. L. JENNINGS. 1966. Movements of immature Mockingbirds between swamp and residential areas of Pinellas County, Florida. *Bird-Banding*, **37**: 113-120.

KATHOLI, C. 1970. Unusual band wear. *Eastern Bird-Banding News*, **33**: 37.

KENNARD, J. H. 1961. Dyes for color marking. *Bird-Banding*, **32**: 228-229.

KNOWLTON, F. F., E. D. MICHAEL, AND W. C. GLAZENER. 1964. A marking technique for field recognition of individual turkey and deer. *J. Wildl. Manage.*, **28**: 167-170.

KOERNER, J. W., T. A. BOOKHOUT, AND K. E. BEDNARIK. 1974. Movements of Canada Geese color-marked near southwestern Lake Erie. *J. Wildl. Manage.*, **38**: 275-289.

KOLZ, A. L., AND R. E. JOHNSON. 1975. An elevating mechanism for mobile receiving antennas. *J. Wildl. Manage.*, **39**: 819-820.

KOLZ, A. L., AND C. W. CORNER. 1975. A 160-MHz telemetry transmitter for birds and bats. *Western Bird-Bander*, **50**: 38-40.

KOSSACK, C. W. 1951. Securing celluloid bands on wildfowl. *J. Wildl. Manage.*, **15**: 335-336.

———. 1952. Banding nestling Mourning Doves. *Bird-Banding*, **23**: 28-29.

———. 1957. Banding tape. *Inland Bird Banding Assoc. News*, **29**: 30.

KOZICKY, E. L., AND H. G. WESTON, JR. 1952. A marking technique for Ring-necked Pheasants. *J. Wildl. Manage.*, **16**: 223.

KUECHLE, L. B. 1967. Batteries for biotelemetry and other applications. AIBS Information Module MIO.

KUCK, T. L. 1966. An improved battery hookup for radio telemetry studies. *J. Wildl. Manage.*, **30**: 858-859.

LABISKY, R. F., AND S. H. MANN. 1962. Back tag markers for pheasants. *J. Wildl. Manage.*, **26**: 393-399.

LAW, J. E. 1929. Worn bands should be replaced. *Western Bird Banding Assoc. News*, **4**: 36.

LEINISH, G. T. 1963. A technique for banding day-old ducklings. *Ornithologiya*, **6**: 394-397.

LENSINK, C. J. 1968. Neckbands as an inhibitor of reproduction in Black Brant. *J. Wildl. Manage.*, **32:** 418-420.

LEOPOLD, A., O. S. LEE, AND H. G. ANDERSON. 1938. Wisconsin pheasant movements. *J. Wildl. Manage.*, **2:** 3-12.

LINCOLN, F. C. 1921. The history and purposes of bird banding. *Auk*, **38:** 217-228.

LINCOLN, F. C., AND S. P. BALDWIN. 1929. Manual for bird banders. U.S. Dept. Agric. Publ. 58. Washington, D.C.

LOCKLEY, R. M., AND R. RUSSELL. 1953. Bird-ringing — the art of bird study by individual marking. London, Crosby, Lockwood and Son, Ltd.

LOHRER, F. E. 1974. Some techniques used in a field study of Loggerhead Shrikes. *Bird-Banding*, **45:** 361-362.

LOVELL, H. B. 1945. Banded song sparrow nestlings removed by parent. *Bird-Banding*, **16:** 144-145.

———. 1948. The removal of bands by Cardinals. *Bird-Banding*, **19:** 71-72.

LOW, J. B. 1945. Ecology and management of the Redhead, *Nyroca americana*, in Iowa. *Ecol. Monogr.*, **15:** 35-69.

LUDWIG, J. P. 1967. Band loss — its effect on banding data and apparent survivorship in the Ring-billed Gull population of the Great Lakes. *Bird-Banding*, **38:** 309-323.

MACDONALD, R. N. 1961. Injury to birds by ice-coated bands. *Bird-Banding*, **32:** 59.

MACINNES, C. D. 1961. Wanted — reports on neck-banded geese. *Inland Bird Banding News*, **33:** 2-3.

MACINNES, C. D., J. P. PREVETT, AND H. A. EDNEY. 1969. A versatile collar for individual identification of geese. *J. Wildl. Manage.*, **33:** 330-335.

MACKAY, R. H. 1957. Movements of Trumpeter Swans shown by band returns and observations. *Condor*, **59:** 339.

MARION, W. R. 1974. Ecology of the Plain Chachalaca in the Lower Rio Grande Valley of Texas. Ph.D. dissertation, Texas A & M University, College Station.

MARSHALL, W. H. 1965. Ruffed grouse behavior. *BioScience*, **15:** 92-94.

MARSHALL, W. H. AND J. J. KUPA. 1963. Development of radio-telemetry techniques for Ruffed Grouse studies. *Trans. N. Am. Wildl. Natl. Resour. Conf.*, **28:** 442-456.

MARTIN, F. R. 1963. Colored vinylite bands for waterfowl. *J. Wildl. Manage.*, **27:** 288-290.

MARTINSON, R. K., AND C. J. HENNY. 1967. Retention of extra-wide, lock-on, and regular bands on waterfowl. U.S. Fish and Wildl. Serv. Spec. Sci. Rep. 108.

MASON, E. A. 1956. Six year old recovery with plastic band. *Bird-Banding*, **27:** 85.

MATHISEN, J. 1966. Patagial tags on Evening Grosbeaks. *Inland Bird Banding Assoc. News*, **38:** 129.

MCENTEE, E. 1953. Concerning color bands. *Eastern Bird Banding News*, **16:** 6-7.

MCEWEN, L. C., AND R. L. BROWN. 1966. Acute toxicity of dieldrin and malathion to wild Sharp-tailed Grouse. *J. Wildl. Manage.*, **30:** 604-611.

MICHENER, H., AND J. R. MICHENER. 1932. Colors induced in male house finches by repeated feather removals. *Condor*, **34:** 253-256.

———., AND ———. 1943. A few results from color-banded Brown Towhees. *Western Bird-Banding Assoc. News*, **18:** 48-50.

MILLER, L. 1940. Observations on the Black-footed Albatross. *Condor*, **42:** 229-238.

———. 1942. Some tagging experiments with Black-footed Albatrosses. *Condor*, **44:** 3-9.

MILLS, J. A. 1972. A difference in band loss from male and female Red-billed Gulls *Larus novaehollandiae scopulinus*. *Ibis*, **114**: 252-255.

MOFFITT, J. 1942. Apparatus for marking wild animals with colored dyes. *J. Wildl. Manage.*, **6**: 312-318.

MOSSMAN, A. S. 1960. A color marking technique. *J. Wildl. Manage.*, **24**: 104.

NAGEL, W. O. 1938. Welding celluloid bands. *Bird-Banding*, **9**: 103.

NEAL, W. 1964. Extra white feather makes bird important. *Inland Bird Banding Assoc. News*, **36**: 69-71.

NELSON, L. K. 1955. A pheasant neck tag. *J. Wildl. Manage*, **19**: 414-415.

NERO, R. W., AND J. T. EMLEN, JR. 1951. An experimental study of territorial behavior in breeding Red-winged Blackbirds. *Condor*, **53**: 105-116.

NICHOLLS, T. H., AND D. W. WARNER. 1968. A harness for attaching radio transmitters to large owls. *Bird-Banding*, **39**: 209-214.

———., AND ———. 1972. Barred owl habitat use as determined by radio-telemetry. *J. Wildl. Manage.*, **36**: 213-224.

NORTH, C. A. 1969. Marking methods for House Sparrows. *Ring*, **5**: 238-242.

OGILVIE, M. A. 1972. Large numbered leg bands for individual identification of swans. *J. Wildl. Manage.*, **36**: 1261-1265.

OWEN, R. B., JR., AND J. W. MORGAN. 1975. Summer behavior of adult radio-equipped Woodcock in central Maine. *J. Wildl. Manage.*, **39**: 179-182.

PARKS, C. 1953. Concerning bands and banders. *Eastern Bird Banding Assoc. News*, **16**: 2-4.

PATTON, D. R., R. T. DICKIE, E. L. BOEKER, AND V. E. SCOTT. 1968. A transmitter for tracking wildlife. U.S.D.A. Forest Service Res. Note RM-114.

PATTON, D. R., D. W. BEATY, AND R. H. SMITH. 1973. Solar panels: an energy source for radio transmitters on wildlife. *J. Wildl. Manage,*. **37**: 236-238.

PESSINO, C. 1968. Observations needed on color-banded terns. *Eastern Bird Banding Assoc. News*, **31**: 123.

PETERS, H. S. 1955. The Mourning Dove banding project of the Fish and Wildlife Service. *Eastern Bird Banding Assoc. News*, **18**: 39-41.

PETERSEN, P., JR. 1962. Banding a Bald Eagle. *Inland Bird Banding Assoc. News*, **34**: 11.

PHILLIPS, G. C. 1955. Sealing celluloid colour bands. *Bird Study*, **2**: 153.

POOR, H. H. 1943. Color-banded immature Herring Gulls in the New York region. *Bird-Banding*, **14**: 101-115.

POULDING, R. H. 1951. The use of extended plastic for colour marking. *Brit. Birds*, **44**: 126-127.

———. 1954. Loss of rings by marked Herring Gulls. *Bird Study*, **1**: 37-40.

PYRAH, D. 1970. Poncho markers for game birds. *J. Wildl. Manage.*, **34**: 466-467.

RAMAKKA, J. M. 1972. Effects of radio-tagging on breeding behavior of male Woodcock. *J. Wildl. Manage.*, **36**: 1309-1312.

RAVELING, D. G. 1976. Do neckbands contribute to starvation of Lesser Snow Geese? *J. Wildl. Manage.*, **40**: 571-572.

REED, P. C. 1953. Danger of leg mutilation from the use of metal color bands. *Bird-Banding*, **24**: 65-67.

RICKLEFS, R. E. 1973. Tatooing nestlings for individual recognition. *Bird-Banding*, **44**: 63.

SAMUEL, D. E. 1970. Banding, paint-marking, and subsequent movements of Barn and Cliff swallows. *Bird-Banding*, **41**: 97-103.

SARGENT, G. C. 1940. Observations on the behavior of color banded California Thrashers. *Condor*, **42**: 49-60.

SARGENT, M. C. 1942. Pacific gull color-banding project. *Condor*, **44**: 78.

———. 1946. Pacific gull color-banding project, 1942-45. *Condor*, **48**: 179-180.

SCHANTZ, W. E. 1939. A detailed study of a family of Robins. *Wilson Bull.*, **51**: 157-169.

SCHREIBER, R. W. 1965. Marked herring gulls. *Bird-Banding*, **36:** 191.

———. 1968. Seasonal population fluctuations of Herring Gulls in central Maine. *Bird-Banding*, **39:** 81-106.

SCHREIBER, R. W., AND L. E. WILLIAMS, JR. 1973. Color-marked Brown Pelicans. *Fla. Nat.*, **46:** 26-27.

SHERWOOD, G. A. 1966. Flexible plastic collars compared to nasal discs for marking geese. *J. Wildl. Manage.*, **30:** 853-855.

SLADEN, W. J. L. 1972. Whistling Swan color marking program. *Inland Bird Banding Assoc. News*, **44:** 94-98.

———. 1973. A continental study of Whistling Swans using neck collars. *Wildfowl*, **24:** 8-14.

SLADEN, W. J. L., AND W. W. COCHRAN. 1969. Studies of the Whistling Swan, 1967-1968. *Trans. N. Am. Wildl. Nat. Resour. Conf.* **34:** 42-50.

SLATER, L. E. 1963. Bio-telemetry — proceedings of the interdisciplinary conference, New York (March 1962). New York, Pergamon Press.

SMITH, R. W. 1965. Bird banding. *Broadsheet* (Gosse Bird Club, Jamaica) **5:** 7-9.

SOUTHERN, W. E. 1964. Additional observations on winter Bald Eagle populations: including remarks on biotelemetry techniques and immature plumages. *Wilson Bull.*, **76:** 121-137.

———. 1965a. Avian navigation. *BioScience*, **15:** 87-88.

———. 1965b. Biotelemetry: a new technique for wildlife research. *Living Bird*, **4:** 45-58.

———. 1971. Evaluation of a plastic wing marker for gull studies. *Bird-Banding*, **42:** 88-91.

SOWLS, L. K. 1950. Techniques in waterfowl nesting studies. *Trans. N. Am. Wildl. Conf.* **15:** 478-487.

———. 1955. Prairie ducks — a study of their behavior, ecology and management. Harrisburg, Pa. The Stackpole Co.

STAMM, D. D. 1967. Species code, recommended leg band sizes, and A.O.U. number of North American birds. *Inland Bird Banding Assoc. News*, **39:** 46-48.

STEENIS, J. H. 1952. Plastic neck bands on Canada Geese. *Eastern Bird Banding Assoc. News*, **15:** 4-5.

STILES, F. G., AND L. L. WOLF. 1973. Techniques for color-marking hummingbirds. *Condor*, **75:** 244-245.

SUGDEN, L. G., AND H. J. POSTON. 1968. A nasal marker for ducks. *J. Wildl. Manage.*, **32:** 984-986.

SWANK, W. G. 1952. Trapping and marking of adult nesting doves. *J. Wildl. Manage.*, **16:** 87-90.

TABER, R. D. 1949. A new marker for game birds. *J. Wildl. Manage.*, **13:** 228-231.

TABER, R. D., AND I. MCT. COWAN. 1969. Capturing and marking wild animals. P. 277-317 *in* R. H. Giles, Jr., ed. Wildlife management techniques. Third Ed. Washington, D.C. The Wildlife Society.

THOMAS, J. W., AND R. G. MARBURGER. 1964. Colored leg markers for Wild Turkeys. *J. Wildl. Manage.*, **28:** 552-555.

TICKELL, W. L. N. 1968. Color-dyeing albatrosses. *Bird-Banding*, **39:** 36-40.

TRIPPENSEE, R. E. 1941. A new type of bird and mammal marker. *J. Wildl. Manage.*, **5:** 120-124.

VAN TYNE, J. 1948. Home range and duration of family ties in the Tufted Titmouse. *Wilson Bull.*, **60:** 121.

WADKINS, L. A. 1948. Dyeing birds for identification. *J. Wildl. Manage.*, **12:** 388-391.

WALLESTAD, R. O. 1971. Summer movements and habitat use by Sage Grouse broods in Central Montana. *J. Wildl. Manage.*, **35:** 129-136.

WEEKS, J. L. 1972. An improved patagial streamer for waterfowl. *Bird-Banding*, **43:** 140-141.

WESTFALL, C. Z., AND R. B. WEEDEN. 1956. Plastic neck markers for Woodcock. *J. Wildl. Manage.*, **29:** 218-219.

WHITTLE, C. L. 1926. Catbirds and colored bands. *Northeastern Bird Banding Assoc. News.*, **2:** 56-57.

WINSTON, F. A. 1954. Status, movement and management of the Mourning Dove in Florida. Fla. Game and Fresh Water Fish Commission Tech. Bull. 2.

———. 1955. Color marking of waterfowl. *J. Wildl. Manage*, **19:** 319.

WOOD, M. 1945. A method of marking celluloid bands. *Eastern Bird Banding Assoc. News*, **8:** 5.

WOODBURY, A. M., AND H. KNIGHT. 1951. Results of the Pacific gull color-banding project. *Condor*, **53:** 57-77.

WORK, T. H. 1964. Watch for marked birds! *Eastern Bird Banding Assoc. News*, **27:** 124.

WRIGHT, E. G. 1939. Marking birds by imping feathers. *J. Wildl. Manage.*, **3:** 238-239.

YOUNG, J. B. 1941. Unusual behavior of a banded Cardinal. *Wilson Bull.*, **53:** 197-198.

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