BREEDING BIOLOGY OF THE SNOWY PLOVER AT CHEYENNE BOTTOMS WATERFOWL MANAGEMENT AREA, BARTON COUNTY, KANSAS

A Thesis

Presented to

the Department of Biology

Kansas State Teachers College, Emporia, Kansas

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

---

by

Roger L. Boyd

May 1972

Robert J. Clarke
Approved for Major Department

Approved for Graduate Council

[redacted]

Frontispiece: Snowy Plover (Charadrius alexandrinus) chick when three days of age. Raised in captivity and drawn by the author 15 June 1971 at Cheyenne Bottoms Waterfowl Management Area, Barton County, Kansas.

ACKNOWLEDGMENTS

I would like to express my sincere appreciation to those persons who have given me assistance during the research and writing of this study. I am indebted to Dr. David F. Parmelee, University of Minnesota, for his encouragement in initiating the study, and to Dr. Robert F. Clarke, Kansas State Teachers College, for his assistance and guidance in preparation of the manuscript.

To Mr. Marvin D. Schwilling, Waterfowl Project Leader for Kansas, is due a special thanks. Allowing access to the study area, countless helpful suggestions and assistance in the field, and the use of equipment and accommodations were indeed appreciated.

I am grateful for field work assistance by Mr. Edmund Martinez, State Entomologist, and by my colleague, Marvin Kraft, Fort Hays Kansas State College. To Dr. E. Raymond Hall and Dr. Robert Mengel, University of Kansas, I wish to express my appreciation for the use of museum materials and helpful suggestions. I am also grateful to Dr. Garnett Hill, Kansas State Teachers College, for his guidance in designing the necessary electrical apparatus employed during this study.

For financial assistance, I am indebted to Kansas State Teachers College for two student research grants for the summers 1970 and 1971, and to the Kansas Academy of Science for a grant awarded by the Research Awards Committee for the summer of 1971.

I wish to thank Dr. Dwight L. Spencer and Dr. Carl W. Prophet, as members of my advisory committee, for reading the manuscript, and offering advice and criticism. To my parents, Dr. and Mrs. Ivan L. Boyd, I express appreciation for their assistance in both the field and in the writing of the manuscript. Last, I wish to express my deepest thanks to my wife, Jan, for many long hours of assistance and encouragement in all phases of this study. This manuscript could never have been completed without the assistance of these and many other persons and to them I express my thanks.

TABLE OF CONTENTS

LIST OF TABLES

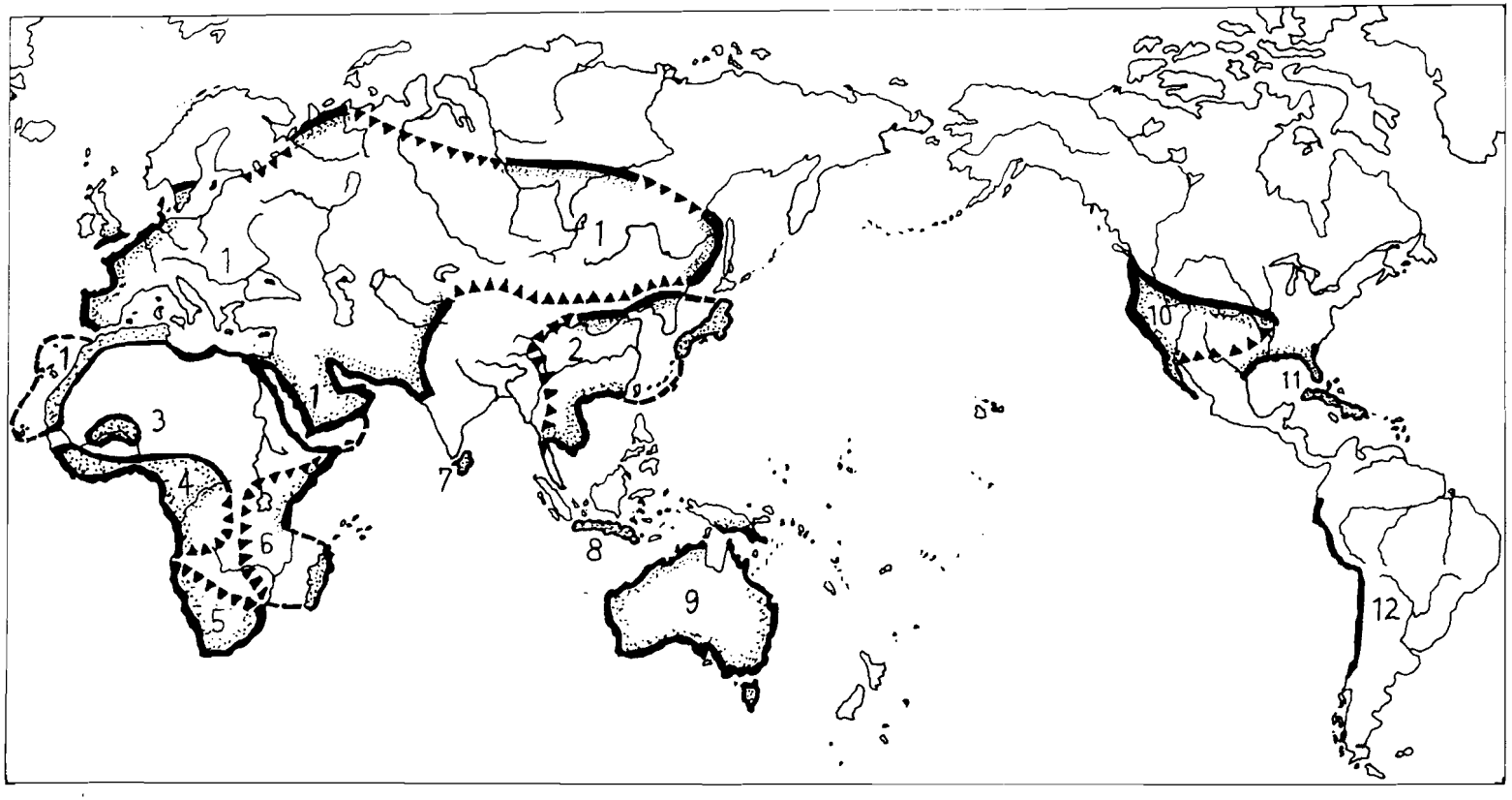
LIST OF FIGURES

INTRODUCTION

The Snowy Plover (Charadrius alexandrinus Linnaeus) is a monotypic, circumglobal species which breeds in the Eastern Hemisphere from the southern parts of England, sporatically across Siberia to Japan, and south to South Africa, Australia, and Tasmania. In the Western Hemisphere, the species occurs from the west coast of the United States inland to Utah and Kansas, along the gulf coast and West Indies, and down the western coast of South America.

There are 13 subspecies of the Snowy Plover, two of which occur in the United States (Fig. 1). One of these, Charadrius alexandrinus nivosus (Cassin), breeds at the extreme of its range in Kansas and is a casual migrant in Nebraska and Missouri (AOU Checklist 1957).

The taxonomic position of this and other species of the family Charadriidae has long been disputed (Jehl 1968). The present research was designed as a preliminary study to aid, in conjunction with similar studies concerning other species of this family, finding a solution to this taxonomic problem. There has been no previous research reported on the Snowy Plover in the United States. Hans Rittinghaus (1956, 1961), however, provided two rather detailed studies of this species on the German North Sea coast. There have also been several accounts of its behavior in British and German journals (Simmons 1951, 1955;



1. Ch. a. alexandrinus (Linnaeus 1758)
2. Ch. a. dealbatus (Swinhoe 1870)
3. Ch. a. nigirius (Bates 1932)
4. Ch. a. mechowi (Cabanis 1884)
5. Ch. a. margiatus (Viellot 1818)
6. Ch. a. tenellus (Hartlaub 1861)
7. Ch. a.leggei (Whistler 1937)
8. Ch. a. javanicus (Chasen 1938)
9. Ch. a. ruficapillus (Temminck 1822)
10. Ch. a. nivosus (Cassin 1858)
11. Ch. a. tenuirostris (Lawrence 1862)
12. Ch. a. occidentalis (Cabanis 1872)

Fig. 1. Map showing the world distribution of the subspecies of Charadrius alexandrinus. (Rittinghaus 1961).

Mühlenberg, 1961). Comparisons will be made between the behavior of the Snowy Pover and the behavior of other species in the family Charadriidae.

This research was conducted at the Cheyenne Bottoms Waterfowl Management Area, Barton County, Kansas. Cheyenne Bottoms was constructed by the Kansas Forestry, Fish, and Game Commission and dedicated as a Waterfowl Management Area in 1957. It has long been an attractive resting place for migrating birds and during occasional wet years, as a favorable area for nesting birds. Interesting accounts of the history and development of the area are found in Howes (1950) and Jencks (1953).

During the 1970 breeding season, daily observations were made from 23 June until 30 July, with additional visits made periodically until the birds departed from the breeding grounds in early October. In 1971, observations began with weekend visits throughout April and May. Daily observations were initiated 25 May and continued until 24 August, followed by several additional visits until the birds departed from the area in late September. During the course of the study, emphasis was placed upon three phases of the breeding cycle: (1) nest construction and courtship, (2) the role of the sexes in care of the eggs and young, and (3) growth, development, and dispersal of the young.

DESCRIPTION OF THE STUDY AREA

Physical Features

Cheyenne Bottoms is a marshy basin in central Kansas near Great Bend in Barton County. This natural basin is six miles wide and eight miles long, surrounded by highland or hills as high as 100 feet above the floor of the basin. The floor of the basin has a relief of only five or six feet (Schoewe 1949). Blood and Deception Creeks, which enter from the north and northwest, are the largest creeks in the watershed of the basin. In addition, the present management area is supplied with water via a canal from the Arkansas River.

The management area consists of 19,000 acres; 12,000 acres of water and 7,000 acres of grassland, salt flats, and crops. Dike roads divide the area into five pools (Fig. 2). By the use of 11 water locks, various water levels can be maintained on the area. Normally, the water level is two to three feet deep in each pool. The center pool (#1) is a storage reservoir surrounded by four peripheral pools (#2, #3, #4, and #5). Hunting during season is allowed from concrete blinds in Pools #2, #3, and #4. Pool #1 and #5 are refuge areas in which no hunting is allowed.

Each year, one or two pools are drained to allow for reconstruction of blinds and planting of millet. An outlet canal returns water to the Arkansas River through the Little

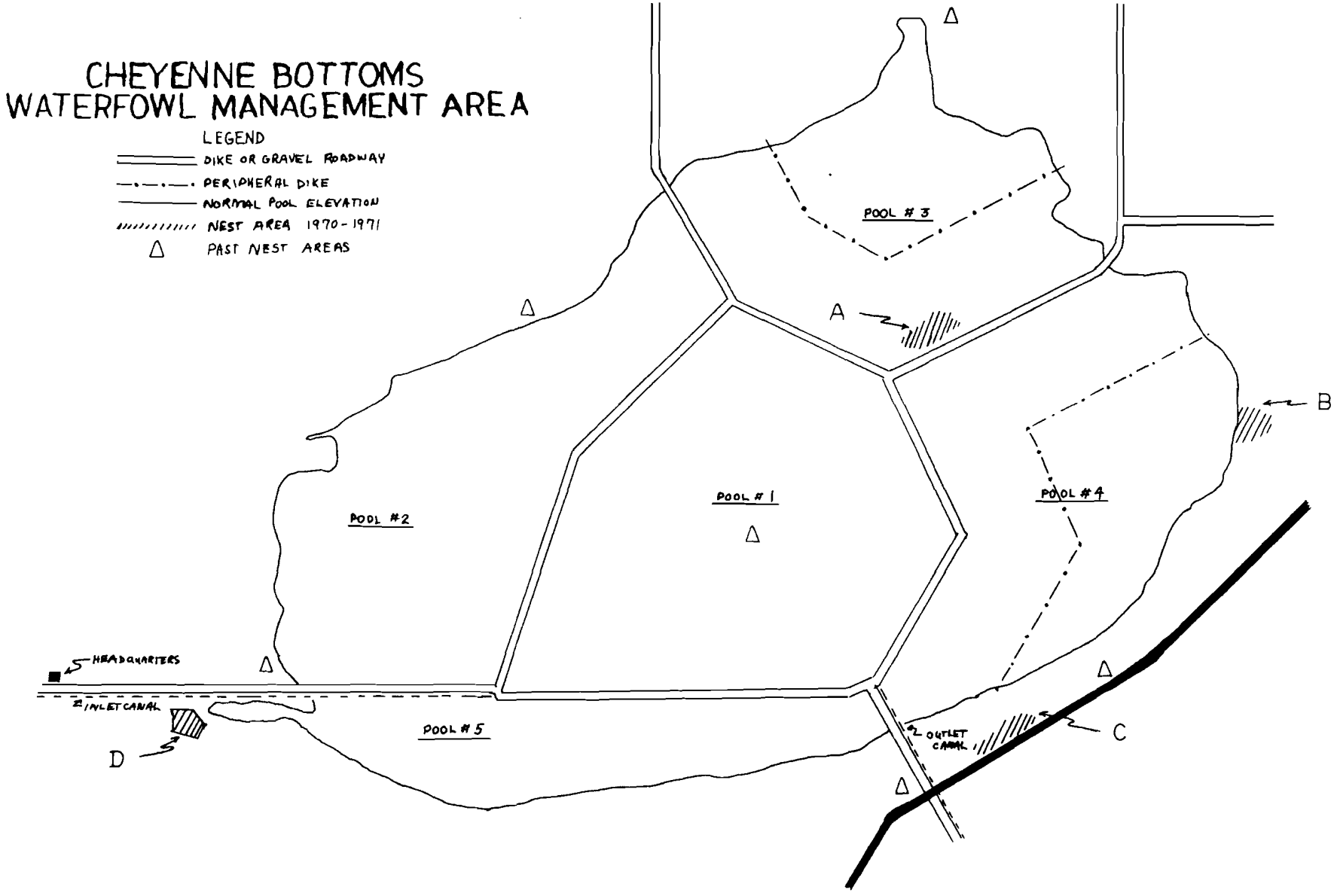


Fig. 2. Snowy Plover nesting areas at Cheyenne Bottoms Waterfowl Management Area, Barton Co., Kansas.

Cheyenne and Cow Creeks, thus preventing an overflow or stagnation.

The rainfall averages more than 24 inches and evaporation averages 55 inches per year. Due to the high rate of evaporation and much more inflow than outflow, the Bottoms has been gradually increasing in salinity. Several areas on the periphery have become denude of vegetation from this build-up of salt and are attractive nesting areas for the Snowy Plover. The large, shallow pools provide an ample supply of food for all types of shorebirds.

Nest Sites and Vegetation

During the two-year study, there were four major nesting areas and several smaller areas of less importance. During the breeding season of 1970, Pool #3 and #4 were being drained for management purposes. Nesting area A (Fig. 2) consisted of approximately 20 acres in early June. This was the first area to be exposed in either pool. Within three weeks, 95 per cent of Pool #3 was dry. The dominant, almost exclusive, plant of this area was spikerush (Eleocharis spp.). By the early part of July, there was substantial growth of inland saltgrass (Distichlis stricta) throughout the area. In 1971 this area was not exposed until mid-August and was not used as a nesting site.

Nesting area B was a salt flat of approximately 2.5 acres (Fig. 3) along the high-water shoreline on the east side of Pool #4. The area was mostly denuded of vegetation, with

Fig. 3. Nesting area B, consisting of a typical salt flat at Cheyenne Bottoms WMA, 1971.

thinly scattered clumps of saltgrass and a few tumbleweeds (Amaranthus graecizans). On the peripheral areas were dense growths of sourdock (Rumex crispus), and squirreltail (Sitanion hystrix).

Nesting area C was under observation in 1971 only. This area consisted of 20 acres of an 80-acre pasture, south of Pool #4. The area suitable for nesting was lower than the surrounding pasture and often was partially submerged during wet periods. Due to the periodic flooding and drying, there had developed a considerable amount of salt on the surface. The major vegetation was inland saltgrass, but by mid-June the drier areas were covered with dense growths of squirreltail.

Nesting area D was the 92-acre goose pen, enclosed by a six foot, small mesh wire fence. The enclosure protected a nesting population of Canada Geese from predators. Approximately 60 per cent of this area was suitable nesting habitat for the plover. Vegetation in the area was saltgrass, squirreltail, and tumbleweeds.

Of lesser importance to this study were areas previously used as nesting sites or areas of unsuccessful nesting. Six of these areas are marked with a "Δ" on Figure 2. Pool #1 was dry in 1963 and Schwilling (personal communication) believed that there were as many as ten pairs of Snowy Plover nesting in the center of the pool that season.

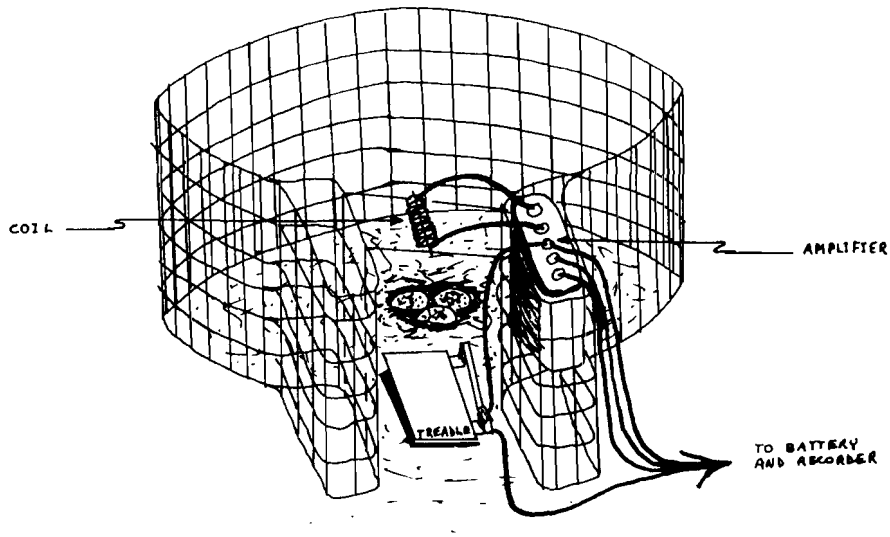
METHODS AND MATERIALS

Nest Location and Observations

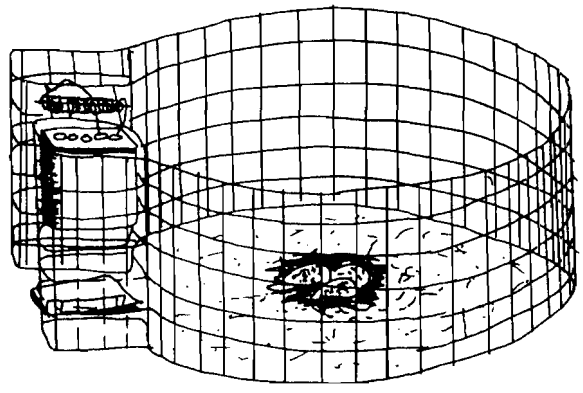
Nests were located by watching or flushing adults. Observations were made from a vehicle or portable canvas blind. A thorough and systematic search was made of several study areas to prevent omission of any nests. This was done by searching a three-meter wide swath while walking between two markers placed at the extremes of the area. At the end of each swath, the markers were moved ahead three m., and the next swath was made. Nest markers, consisting of a 50 cm. wire rod with a small label attached, were placed 5 m. east of each nest for consistency and for lessening predator detection of the nest. On each label was recorded vital information, i.e., the nest number, the date the nest was found, and when the eggs were laid. Certain eggs were marked with a ball point pen for identification purposes.

Nest Activity Recording

The recording of activity at the nest was accomplished by two methods. First, the nest was observed for periods of time, as described above, to determine a general trend in the activity of the birds. A second method was designed to record accurately nesting activity on a 24-hour basis. A corral (Fig. 4) was placed around the nest, allowing the birds only one entrance. This corral was constructed of one-half inch wire mesh, 18 cm. tall



FRONT

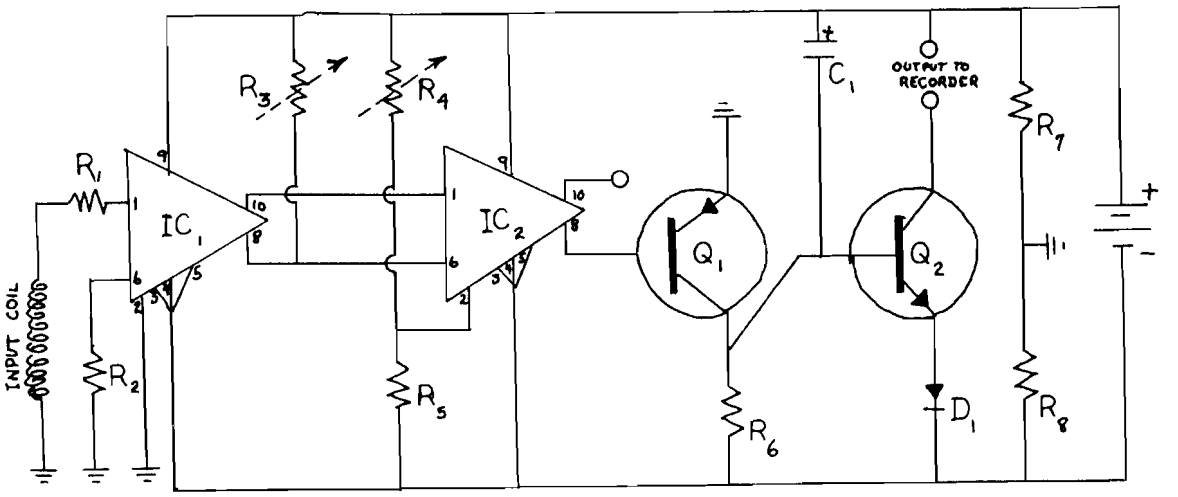


SIDE

Fig. 4. Front and side view of the nest activity recording apparatus.

and one m. in circumference. A treadle switch, placed in the entryway, was linked to a Simpson 2755 miniature 10-channel event recorder which was operated by a 12-volt car battery. Both the battery and recorder were placed a minimum distance of 30 meters from the nest. Upon entering the nest, either bird would activate the treadle and the activity would be recorded on the event recorder. On the back of one of the birds was fastened a magnet 3.0 x 0.6 x 0.2 cm. Elmer's Clear Cement was found to set well enough in 15 seconds to secure the magnet onto the bird's feathers, and remain until later molted in the breeding season. Observations did not detect any interference or ill effects caused by this method of labeling the birds. As the bird and magnet passed through the entrance of the corral, a small electrical current was produced through a copper wire coil placed over the entrance (Fig. 4). An amplifier (Figs. 4 and 5), designed and constructed by the author, increased the small input voltage produced through the coil and activated the event recorder. The treadle and coil-amplifier relay were linked to separate channels on the recorder so that the unmarked bird produced one mark and the specially marked bird produced two marks on the chart upon entering and leaving the nest.

The basic components of the amplifier were two RCA linear integrated circuits. Two transistors, used as power amplifiers, provided the extra current needed to activate the recorder Resistors three and four (Fig. 5) were adjusted for zero DC output voltage, with respect to ground, at pins eight and ten



PARTS LIST

R_1, R_2 - 1 K Ohm	Q_1 - 2N107, PNP Transistor
R_3 - 500 K Ohms	Q_2 - 2N3404, NPN Transistor
R_4 - 6.4 K Ohms	IC_1, IC_2 - CA3000, RCA Integrated Circuit
R_5 - 82 K Ohms	C_1 - 5 pf @ 25 Vdc
R_6 - 12.5 K Ohms	D_1 - IR 10C6, Diode
R_7, R_8 - 500 K Ohms	Input Coil - 2000 Turns, 100 Ohms #38 Gauge Wire.

Fig. 5. Schematic and parts list for Integrated Circuit Amplifier.

on both integrated circuits. For a more detailed description of this and other modes of use, refer to RCA Linear Integrated Circuits (1967).

Precautions were made to secure the amplifier and all connections from moisture. This was done by placing the amplifier in a water-tight can, sealing it, and using banana plugs as external connections. The container was painted beige to aid in camouflaging the instrument.

Capturing and Marking Techniques

It was necessary to use several methods to capture the birds for the purpose of banding and color marking. Incubating Snowy Plovers were caught on the nest by means of a quonset-shaped trap placed over the nest (Fig. 6). One side of the trap rested on the ground while the opposite side was propped up 15 cm. by a stick. The cage was placed so that the nest was at the back. The stick was placed on a small hard object to prevent the stick from digging into the sand, and on windy days the back of the trap had to be anchored with small wire stakes. A nylon fishing line, actuated by the observer, was tied to the bottom of the stick and used as the tripping device from a concealed observation spot. Wilcox (1959) used a similar method of capture for Piping Plover (Charadrius melodus). In 1970, there were 14 females and three males captured on 15 nests by this method. Two of those nests were eventually abandoned, even though the birds returned to the nest for several

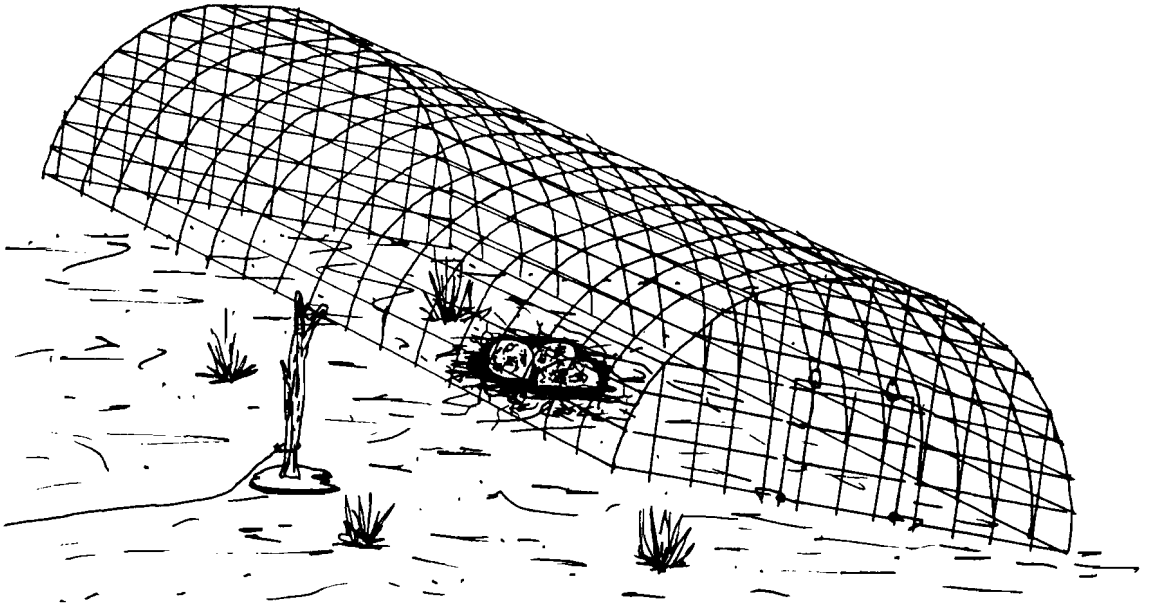


Fig. 6. Trap used to capture incubating adults. It was constructed of one-half inch screen mesh.

days. Likewise, in 1971, two of 19 nests were eventually abandoned out of 16 females and 12 males captured. It was felt that the nests were not abandoned due to the method of capture.

All adult birds captured were painted on the rump and tail. Five colors of pressurized fluorescent spray paint were used in marking the birds, each color representing the area in which the bird was captured. The adult birds were also banded with numbered aluminum bands from the Fish and Wildlife Service. Those captured in 1971 were banded, in addition, with plastic colored bands, obtained from A. C. Hughes, Middlesex, England. Edmund Martinez (personal communication) determined that banding shorebirds on the tibia, rather than on the tarsus, increased the life span of the band. This is due to a decreased amount of friction and corrosion related to their habitat. In the present study, all of the aluminum bands were placed on the tibia. The color bands were made of plastic and not subject to wear, so they were placed on the tarsus in order to identify the individual more readily in the field (Frontispiece).

The young could be banded immediately after hatching, but on several occasions the young had already left the nest and had to be caught by hand. The protective coloration of the downy chicks was extremely effective in concealing their position, even on an exposed salt flat, as also noted by Bent (1929), and it usually required two people to catch the chicks after first locating them. One person would maintain surveillance with a spotting scope, while the other person was directed to

the location. Mist nets were used in choice feeding areas to capture a number of the birds, which included adults and fledged juveniles.

RESULTS AND DISCUSSION

Arrival and Breeding Density

Snowy Plovers usually arrive at the Bottoms in the early part of April. In 1971, several birds were seen on 2 April, but the earliest date of arrival was 31 March 1963, when Schwilling (unpublished notes) saw three birds. Water levels were usually high in early April and previous nesting sites were submerged. For this reason, the majority of the clutches were completed in mid-June, with the exception of an early clutch recorded 24 April 1971.

Breeding locations vary from year to year because of the fluctuation of available nesting sites. Breeding density, however, was nearly the same in 1971 as in 1970. Twenty nests were found in 1970. In addition, five different clutches were identified after hatching, based upon differences in location or age. There were 27 nests found in 1971, with five additional clutches also identified after hatching. This would indicate between 25 and 30 breeding pairs each year.

Distance between nests was measured in 17 instances, with an average distance of 85 m. between nests. The distances between the two closest nests were 15 and 20 m. Of the 17 distances measured, 10 were less than 60 m. At the Quivira National Wildlife Refuge, 35 miles to the southeast, 100 plovers were seen from one spot in 1971. Four nests of the

species were found in a relatively small area. Ken Schwindt (personal communication), one of the staff at the Great Salt Plains National Wildlife Refuge in northern Oklahoma, has estimated the breeding population of Snowy Plovers there to be 1500. When I visited the area, only three nests were found. The distance between the first and second nest and the second and third nest was 80 m. and 100 m. respectively. Schwindt (personal communication) noted that many nests had been destroyed by flash flooding and hail during a recent storm.

Nests at Cheyenne Bottoms were clumped. This would not be evidence enough to state that the plovers would always nest in colonies, for the salt flat areas were also clumped. Ken Schwindt (personal communication) varified, however, that the plovers nested in colonies at the Great Salt Plains Wildlife Refuge, even though suitable nesting habitat was widespread.

Nest Construction and Courtship

Differentiation of the sexes was possible according to the shade of the plumage behind the eye and over the forehead (Figs. 7 and 8). In all cases observed, the male was always darker, either over the forehead or behind the eye or both. Often, the differentiation was accentuated by the male being darker on the back, with a gray coloration, while the female was light brown or beige on the back. Measurements of wing, tarsus, and culmen were made on 16 males and 30 females. These measurements were compared by sex and to the subspecies Charadrius

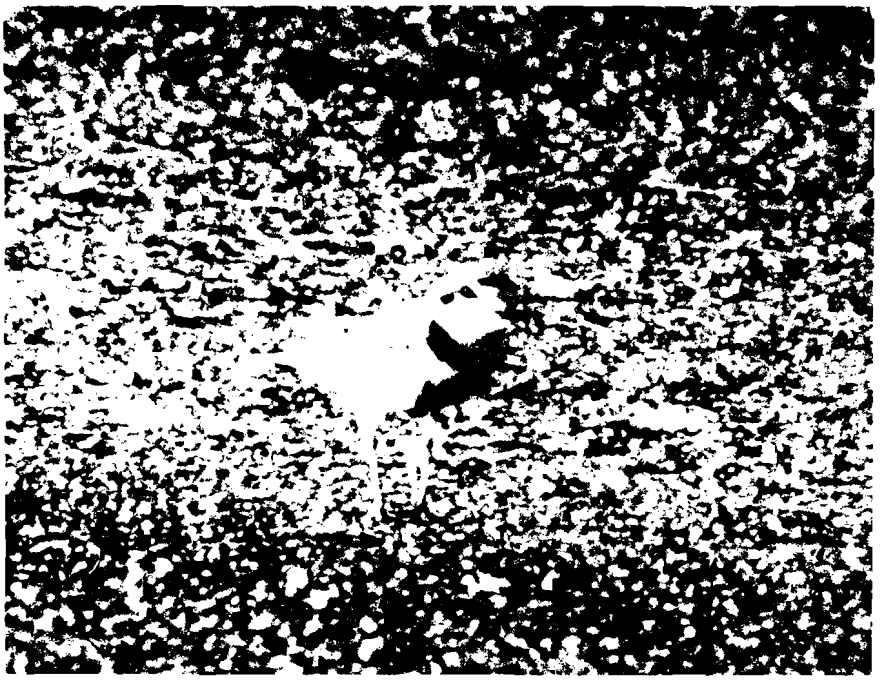


Fig. 7. Female Snowy Plover at Cheyenne Bottoms WMA, 1971.

Fig. 8. Male Snowy Plover at Cheyenne Bottoms WMA, 1971.

TABLE I. The range and average of measurements[1] of male and female Snowy Plover[2].

	Male		Female	
	Range	Average	Range	Average
Wing				
Ch.a.nivosus	99 - 108	104.0	98 - 109	103.1
Ch.a.alexandrinus	105 - 117	111.7	107 - 116	111.1
Culmen				
Ch.a.nivosus	15 - 16	15.6	14 - 16.5	15.1
Ch.a.alexandrinus	14.2-16.7	15.2	14.3- 14.6	14.9
Tarsus				
Ch.a.nivosus	21 - 27	25.5	23.5- 28	25.4
Ch.a.alexandrinus	...	...	...	...
Weight				
Ch.a.nivosus	...	...	...	...
Ch.a.alexandrinus	41 - 54	47.3	42 - 55	46.9

1 Measurements are in millimeters, weight in grams.

2 *Charadrius alexandrinus nivosus* measurements were taken during this study on 16 males and 30 females. *Charadrius alexandrinus alexandrinus* were taken by Rittinghaus (1961) on 100 males and 100 females.

alexandrinus alexandrinus in Table I. There were proportionate differences between sex in the wing and culmen measurements of both subspecies. It could be noted that these measurements were not significant enough to aid in sex differentiation. Table II shows measurements of four birds during 1970 and 1971. The difference of wing measurements might indicate that M808 and F820 were one year old in 1970. The wing of F834 measured only 98 mm. when she was one year of age. Rittinghaus (1961) noted a similar change with age. According to him, wing measurements average 108.5 mm. for one year old birds and 110.8 mm. for two year old birds.

I was not able to observe pairing displays, but Rittinghaus (1956) described the display as being rather subdued. On the other hand, Palmer (1967) described the male Snowy Plover as having a slow butterfly courtship flight with a trilling call. Rittinghaus (1961) observed only minor aggressive encounters by males over a female, and pairing appeared to be more by mutual attraction than by attraction of a female to displaying males. The birds were believed not to be paired prior to arrival in early April 1971, as early arrivals were often in odd-numbered groups and individuals did not demonstrate partiality toward certain birds in the group.

There were no instances where birds were found to have mated with the same bird in 1971 as in 1970. In two instances, birds that had been banded in 1970 were recaptured in 1971 with a new mate. In one situation, a male (107-160776), which had been banded 25 August 1968 at Cheyenne Bottoms WMA by Edmund Martinez,

TABLE II. Variation from 1970 to 1971 in measurements of the Snowy Plover (Charadrius alexandrinus nivosus) at Cheyenne Bottoms WMA.

	1970			1971		
Band Number	Wing	Tarsus	Culmen	Wing	Tarsus	Culmen
101-116801M	108	-	16	108	25	16
101-116808M	103	26	15	107	26	15
101-116820F	102	26	15	106	26	15
101-116834		Juvenile		98	23.5	14

Measurements are in millimeters.

was recaptured on a nest in area C by me 29 May 1971. Its mate was also captured 29 May 1971 and had been banded as a juvenile by me 22 July 1970 in area A. Another case was a female (101-116820), which was captured on a nest in area B with the male (101-116821) on 12 June 1971. The female (820) was recaptured on a nest in area D, 7 July 1971. Its new mate (112-152923) was captured on this nest in area D on 28 June 1971.

Rittinghaus (1956) gave examples of the duration of partner bonds from 1947 to 1948. Eighty-nine pairs (178 birds) were banded in 1947. Of these, 96 were birds that returned in 1948. Twenty-six were "widowed" but mated with new mates. Forty-two birds returned and mated with new mates even though their mates of last year were also in the area and mated to new birds. Twenty-eight birds (14 pairs) remained together from 1947 to 1948. Several other examples were cited; one pair remained together for six years, another female mated with one male for four years and then with a different male for another three years. This information suggested that some pairs remain together all year round.

Wilcox (1959) banded 1173 nesting adult Piping Plovers and recaptured only 38 pairs which mated with each other more than one year, but not always in consecutive years. The longest that Wilcox found one pair remaining together was three years.

Once paired, both sexes defended the nesting territory against any approaching bird or other animal. Both birds were quite capable of defending their territory from larger

birds, such as Killdeer (Charadrius vociferus) and Avocets (Recurvirostra americana), with which they often nested in close association.

The male had the primary responsibility in selecting the nesting site. Rittinghaus (1956) demonstrated this with a male which nested in the same spot six years, with five different females, and then the seventh year the male nested only 18 m. away from the previous site. Wilcox (1959) found that the Piping Plover nested near to where the male had hatched or previously nested, thus indicating the strong influence on site selection by the male of that species.

Snowy Plover's nests were often located next to an object, such as a brick, a tumbleweed stalk, grass clumps, or even a goose skeleton (Figs. 9, 10, 11, 12). W. Lee Chambers (Bent 1929) noted that nests of these species were, as a rule, found by a mark of some kind, a bone of some animal, a small dead weed, or a bit of driftwood. In construction of the nest, the male made a depression, 1.0 to 2.5 cm. deep and 7.0 to 9.0 cm. wide, by leaning forward on his breast, scratching with his feet while rotating on his axis two to three times (Fig. 13). While scratching, the bird would reach out and pick up loose debris, such as small sticks, snail shells, gravel, or mud balls, and place them on the edge of the nest. The process of placing material in and around the nest will be referred to as transporting. This procedure would often be interrupted while the male moved out from the nest as far as two and one-half m., all the while picking up debris and tossing it behind him with a movement of the head to the side

Fig. 9. Snowy Plover nest found next to bricks, 25 June 1970, at Cheyenne Bottoms WMA.

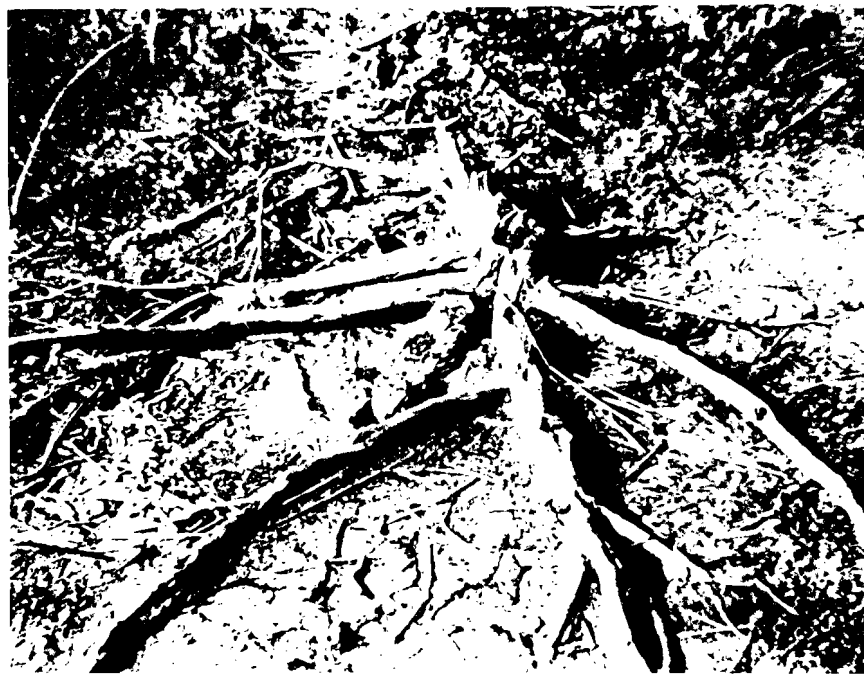


Fig. 10. Snowy Plover chicks only a few hours old in a nest located next to an old tumbleweed stalk, on 16 July 1971, at Cheyenne Bottoms WMA.

Fig. 11. Snowy Plover nest located within a small clump of inland saltgrass, 24 June 1970, at Cheyenne Bottoms WMA.

Fig. 12. Snowy Plover nest located inside of a Giant Canada Goose skeleton in area D, 19 June 1971, at Cheyenne BottomsWMA.

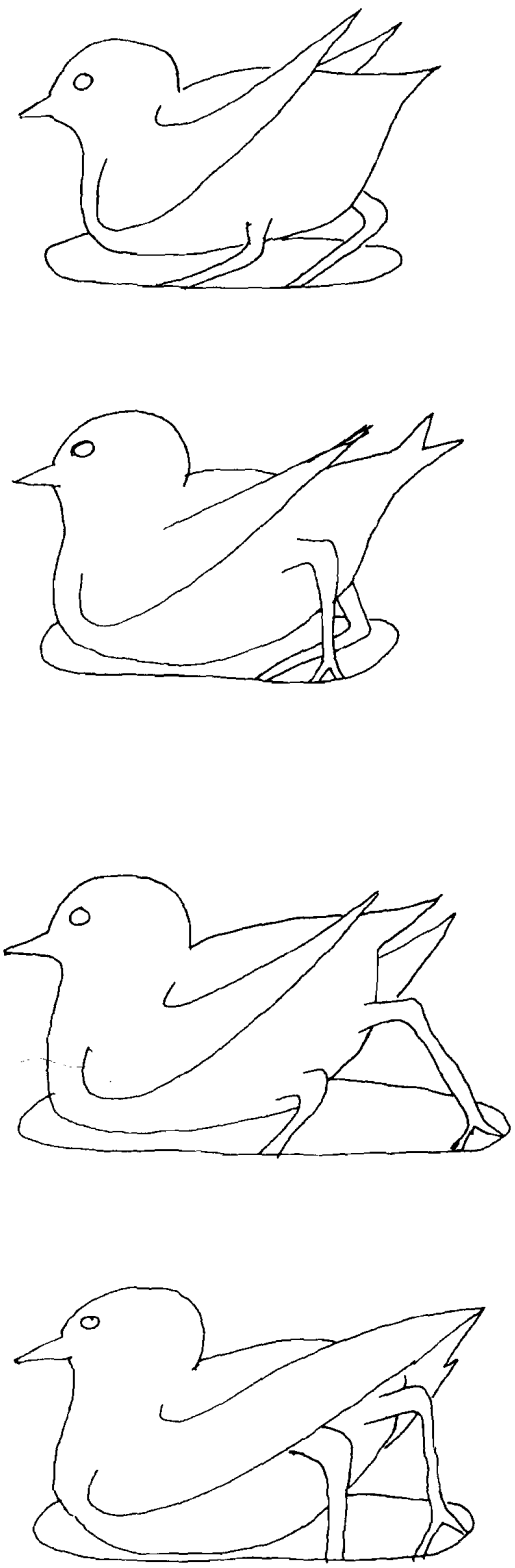


Fig. 13. The series of phases during the scratching of the nest scrape. (Taken from 16 mm. film by Rittinghaus, 1961, p. 35.)

Fig. 14. The tossing of debris at the nest. (Taken from 16 mm. film by Rittinghaus, 1961, p. 35.)

(Fig. 14). Wilcox (1939, 1959) made no mention of nest construction or nest contents of the Piping Plover. Pickwell (1925) mentioned the nest contents of the Killdeer as being small pieces of gravel and sticks around the edge, but made no mention of construction. I observed the same method of scratching and transporting of nesting materials by the Killdeer, as described above for the Snowy Plover. Bailey and Niedrach (1965) noted, about the Killdeer, "the male does most of the nest-making, with the female giving only token assistance, sometimes the nest being just a depression scantily lined, and again it may be a mosaic of nicely laid fine stones." Bradbury (1918) and Laun (1957) both stated that the Mountain Plover (Charadrius montana) excavated a small depression but they attributed the lining of grasses and root fibers to the wind. Bailey and Niedrach (1965) stated that the Mountain Plover placed the lining in the nest scrape.

Often, the male Snowy Plover constructed two or three scrapes several meters from the first. W. Lee Chambers (Bent 1929) found that a pair of Snowy Plovers would build several nests during the season and use only one. When the bird moved from one scrape to another, the tossing of material continued. The head was flipped in the same manner each time. Thus, when the bird changed course, it was evident that what previously appeared to be a conscious effort, on the part of the bird, to direct the tossed material towards the nest, was a display of instinctive behavior. As the bird turned, the tossing continued in the same manner, but the material landed in a direction behind

the bird and not in the nest. Only when the bird had its back to the nest did the material land in the direction of the nest. Over the period of time in which the scrape was built, transporting increased in intensity and, as shown in Figure 15, a considerable amount of material was placed around and in the nest. Armstrong (1947) explained that nest-building displays were caused by emotional excitement. This could be demonstrated by the increased intensity of scraping and transporting by the male as the female approached him.

The male, as his mate approached, scurried off four to five m. in the typical manner of running rapidly and stopping abruptly, but returned in an entirely different manner. His legs became stiff with the dorsal side of the bird forming a straight and horizontal line (Fig. 16). The head was outstretched, bill pointed horizontally with the tail also raised to the horizontal. The throat feathers were ruffled and a soft and deep gutteral "pikoor" (as defined by Rittinghaus, 1956) was uttered. The bird appeared as in a crouched position without going to the heels, and in this state moved with deliberate steps towards the scrape. I will refer to this as the "horizontal dance." At times, the bird would become stationary, raising one foot at a time high in the air and methodically placing it in the same spot, as though he were marking time.

Upon reaching the nest, if the female did not come to the scrape, the male again began scraping, and the horizontal dance might be repeated. If the female was standing next to the

Fig. 15. Snowy Plover nest located on the salt flat in area C, 24 April 1971. This nest illustrated the large amounts of debris which accumulated from transporting.

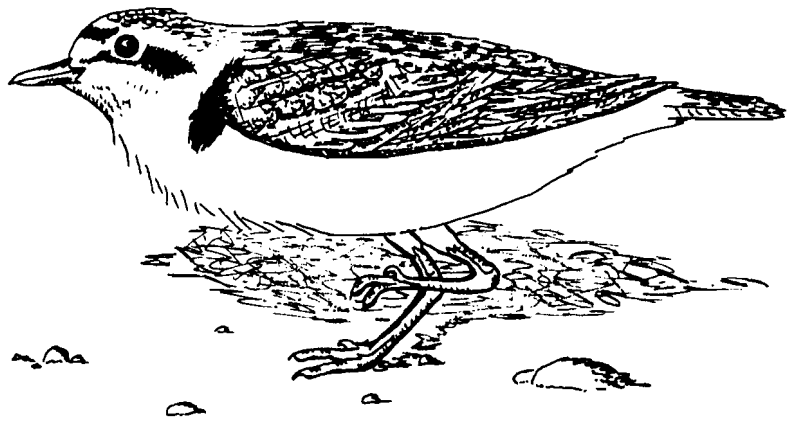


Fig. 16. The posture of the male during the "horizontal dance".

nest, the male then began another courtship ritual. He stood on the edge of the nest as though on his tiptoes with head bowed and bill pointed into the nest. His excitement was shown by quivering and with the excited flashing or spreading of the white outer tail feathers on the side away from the nest. The tail was raised approximately 30 degrees above the horizontal and fanned upwards away from the nest (Fig. 17). At the same time, the wing away from the nest was raised and partially spread. The inside wing was slightly drooped. The female sat down in the nest and scratched while turning around as the male had done. She then jumped from the nest and ran off a distance of approximately one m. The male followed with the horizontal dance again, pausing halfway between the female and the nest to prance in place. This procedure was conducted at each of the scrapes, over a period of two to eight days, as though allowing the female to "choose" the suitable scrape. If the female had remained passive during the horizontal dance or nest-showing display, apparently she had not yet been adequately stimulated.

After leaving the nest, the female raised her tail and displayed the white bordered cloaca as a signal to the male that she was prepared for copulation. Otherwise, the female flew or ran off, and the horizontal dance and nest-showing display was repeated at a later time. Mühlenberg (1961) explained in detail the importance of this signal prior to copulation. I have never recognized this signal, for it occurred so rapidly that only the male immediately behind her or a person with a motion picture

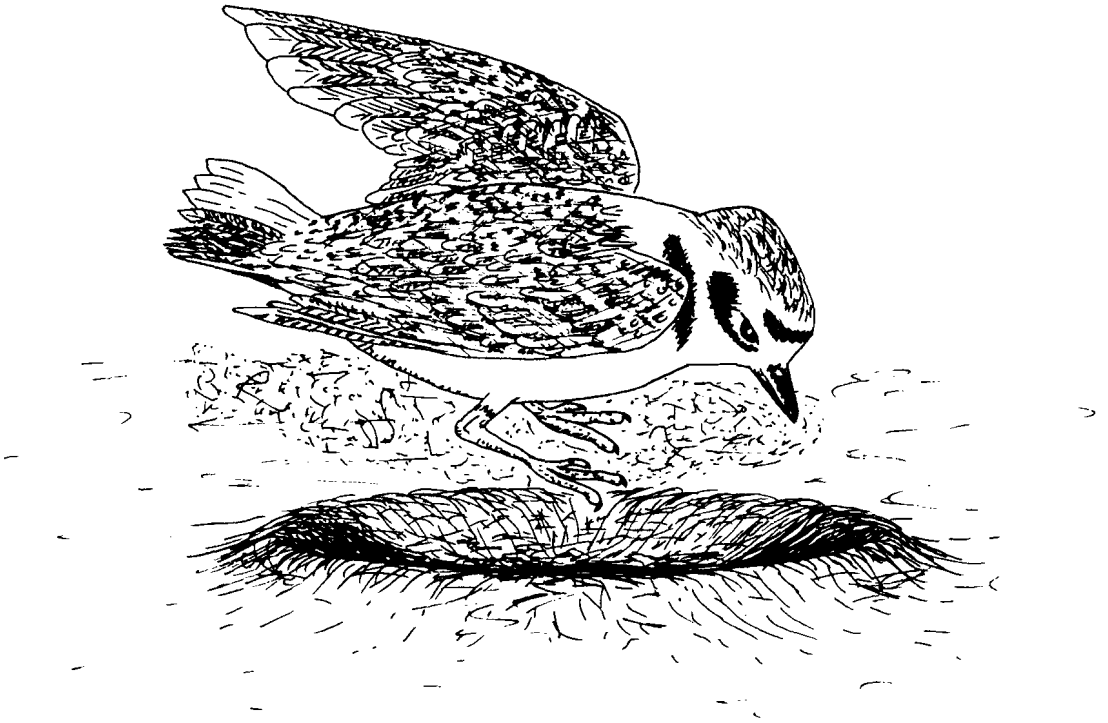


Fig. 17. The posture of the male at the nest.

camera (Rittinghaus 1961) could distinguish this movement. I have observed copulation on six occasions, but was not able to photograph it. Because of lack of a motion picture camera, I used Rittinghaus' (1961) account and drawings (Fig. 18) made by him from motion pictures.

Upon receiving the signal from the female, the male jumped onto the back of the female, during which time the wings were flapped to help attain the point of balance. The male stood on the pelvis of the female, who stood as though on tiptoes with head bowed which indicated efforts to maintain balance (Fig. 18a). After the male was secure, he lowered himself onto the female so that his belly touched her back (Fig. 18b).

His wings remained close to his body while his legs were in motion, as though he was stepping while sitting, moving from one leg to the other. The tail was moved back and forth with a gentle rhythm. This was probably necessary for stimulation of the female, as well as the male. This state continued from 1.5 to 2.5 minutes while the female stood quietly, only moving her tail in the opposite direction as that of the male. I noticed an increase in the frequency of the tail movements toward the end of the period. Suddenly, the male hit the female's tail powerfully with his tail, and coitus was established. The female still showed no excitement, but tried to maintain balance with a deep inclination of the breast and head (Fig. 18c). The male then grasped the feathers on the nape of her neck with his bill in order to maintain balance, beating the wings rapidly. This

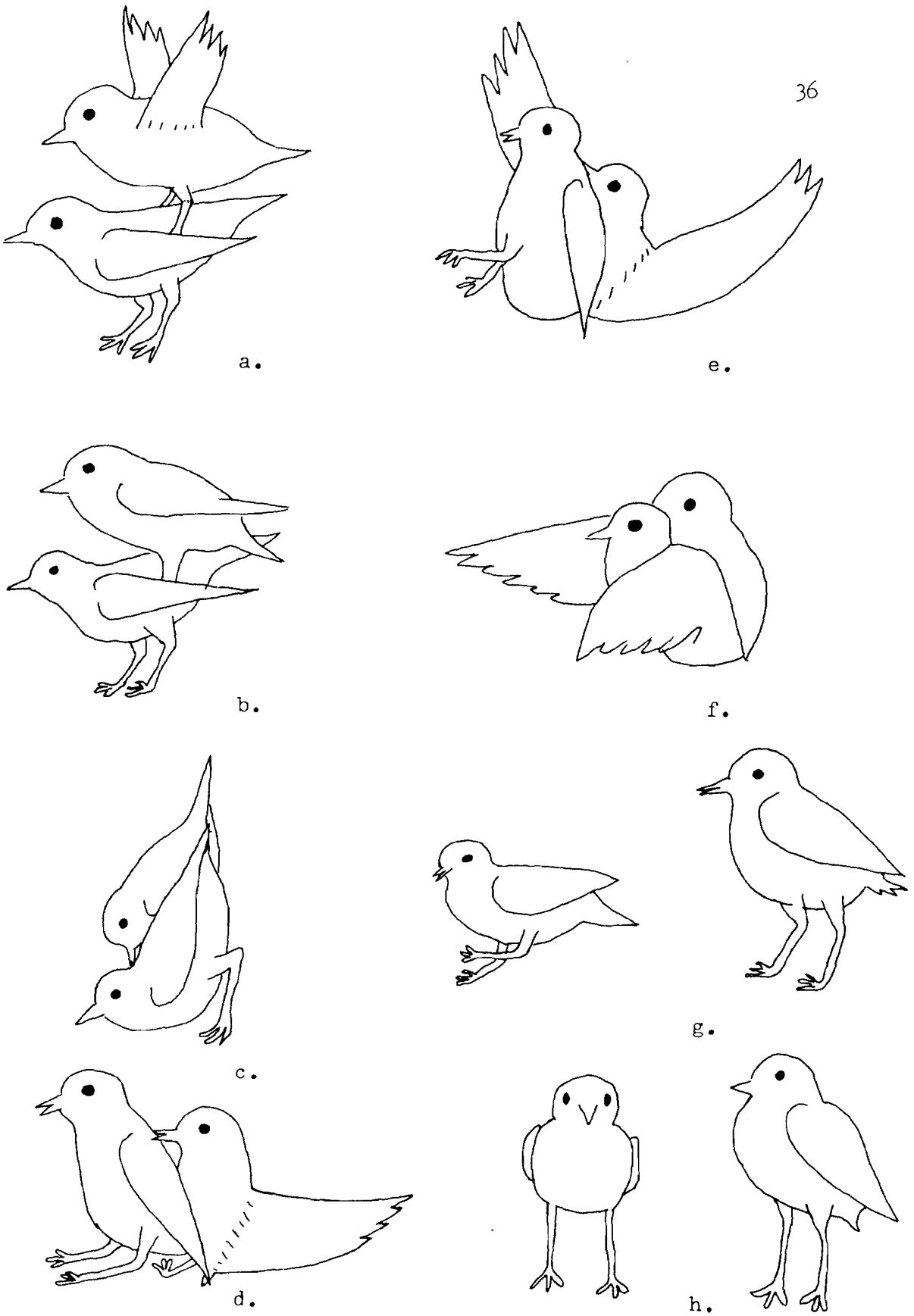


Fig. 18. The series of phases during copulation. (b. thru h. taken from 16-mm. Film by Rittinghaus, 1961, p. 39.)

position, during which the sperm probably was delivered, was maintained only a fraction of a second and, as in the showing of the cloaca, cannot be readily discerned without a motion picture camera. Even then, the films with a normal frequency were not able to follow the event in detail. In the next moment, both toppled over backwards (Fig. 18d), and remained together sitting on their rumps for a moment. It appeared that the last shove was so powerful that the partners fell over backwards. At that point, it could be established that the male had clamped onto the flanks of the female with his legs and was still holding on to her neck feathers. The legs of the female swung in the air while she sat on her tail "in the lap of the male" (Fig. 18e). At first, the male, although sitting on the ground, still carried out distinctly visible back and forth movements with his posterior, as though he was "not yet finished" and then suddenly he released the female (Fig. 18g). Both jumped up and shook themselves (Fig. 18h). The female either returned to the scrape and scratched for several minutes, or preened for 10 to 15 minutes. The sounds which were made by the male at the moment of coitus encompassed the entire scale, from the deepest, gutteral, hoarse screeches to the clearest "mood feeling" or alarm call. All of this was rather soft and difficult to hear from a distance. Rittinghaus (1961) observed that copulation could occur several times in one day. I observed it only once a day, and only between 1830 and 2045 hours, with the exception of one instance at 1130 hours (Table III).

Copulation can be terminated by lack of willingness or stimulation of the female and also by outside disturbances. On one occasion, the male had been on the female's back for 1.5 minutes when a neighboring female approached to within five m. The male immediately stopped the methodical motion of his tail and stood up on the female's pelvis and launched himself into flight from this position, in pursuit of the intruder.

In contrast to the Ringed Plover (Charadrius hiaticula), whose display and copulation could occur anywhere within its breeding area (Laven 1940), the display and copulation of the Snowy Plover was related to a specific location - that of the scrapes. For this reason, the pair must always come to the nest scrape for this ritual. In the six instances observed, each occurred within one m. of the scrape. One pair copulated on two occasions within 30 cm of the nest scrape.

Copulation of the Killdeer was observed three times. The first was one m. from the nest scrape, the second was not in the vicinity of a scrape. The third occurred 0.5 m. from a Killdeer scrape, but 12 m. from the scrape where the eggs were eventually laid. This indicates that the Killdeer was also restricted to the nest scrape for copulation, as is the Snowy Plover.

TABLE III. Occurrence of copulation of the Snowy Plover at Cheyenne Bottoms WMA.

Nest	Date	Nest Status
10 A	1130, 25 June 1970	First egg laid approx. 1615, 25 June.
1 C	1830, 24 April 1971	First egg 22 April, second egg prior to 1830, 24 April.
2 C	1945, 28 May 1971	Empty scrape.
	2045, 30 May 1971	Empty scrape, first egg 1 June.
GPR	1900, 17 June 1971	Empty scrape, first egg prior to 1530, 18 June.
	1945, 18 June 1971	One egg, second egg laid 20 June.

Egg Laying and Incubation

The maximum clutch size for the Snowy Plover was three eggs. According to Palmer (1967) the only other North American plover to have a normal clutch of less than four eggs was the Wilson's Plover (Charadrius wilsonia). Of the 45 nests found, 32 contained three eggs each, nine contained two eggs, and four contained one egg. All of the nests containing only one egg had been abandoned and were never completed.

The eggs were short, ovate in shape, and without gloss. The ground color was olive-buff, randomly covered with small spots, dots, or little scrawls of black, and fewer blotches of pallid gray (Fig. 19). The measurements of 38 eggs averaged 31.7 by 23.1 mm. The eggs showing the four extremes measured 34.2 by 22.3, 32.0 by 24.0, 29.4 by 23.3, and 32.5 by 22.2 mm. Rittinghaus (1961) gave the average of 100 eggs as measuring 32.8 by 23.4 mm., and Bent (1929) determined the average for 51 eggs at 30.4 by 22.3 mm.

When the female came to the nest to lay the egg, there was no display by the male. After the egg had been laid, the female either sat on the egg, preened herself while standing on the edge of the nest, or flew to the water's edge. Two females were observed to limp prior to laying the egg, but commenced normal walking after completion of the clutch.

In several instances after the first egg had been laid, the male sat on the nest, or at least stood over the egg for short periods of time, five to 15 minutes. Welty (1963) stated that

Fig. 19. Snowy Plover egg from nest located in goose skeleton, 19 June 1971, at Cheyenne Bottoms WMA.

studies with thermocouples in the nests of a bird have shown that a bird may sit on the eggs without warming them. After each egg was laid, more debris was added to the nest scrape. Figures 20 and 21 illustrate this change in one nest, from a deep and almost empty scrape, to one which was filled with gravel around two eggs.

Rittinghaus (1956) stated that the first egg was laid three to four days after copulation first occurred. Table III shows six cases in which copulation was observed during the present study. The last four cases were two to five days prior to an egg being laid. Rittinghaus (1956, 1961) also stated that the onset of laying was greatly influenced by temperature. He found that once the temperature exceeded 50°F the greatest number of eggs was laid. Since the temperatures at Cheyenne Bottoms in early April exceeded 50°F, temperature was not a determining factor.

The general pattern for completion of the clutch occurred over a five day period. One egg was laid on the first, third, and fifth day, and incubations usually began upon the laying of the third egg. The incubation period of eight clutches was accurately determined. Five of the clutches hatched in 26 days, two in 25 days, and one in 24 days, for an average of 25.5 days. Rittinghaus (1961) found the incubation period to vary between 24 and 28 days, showing an average of 26.3 days. This is in the middle range, as compared with the shorter incubation periods of 22 to 28 days for the Ringed Plover (Laven 1940) and 23 days for the Semipalmated Plover (Charadrius

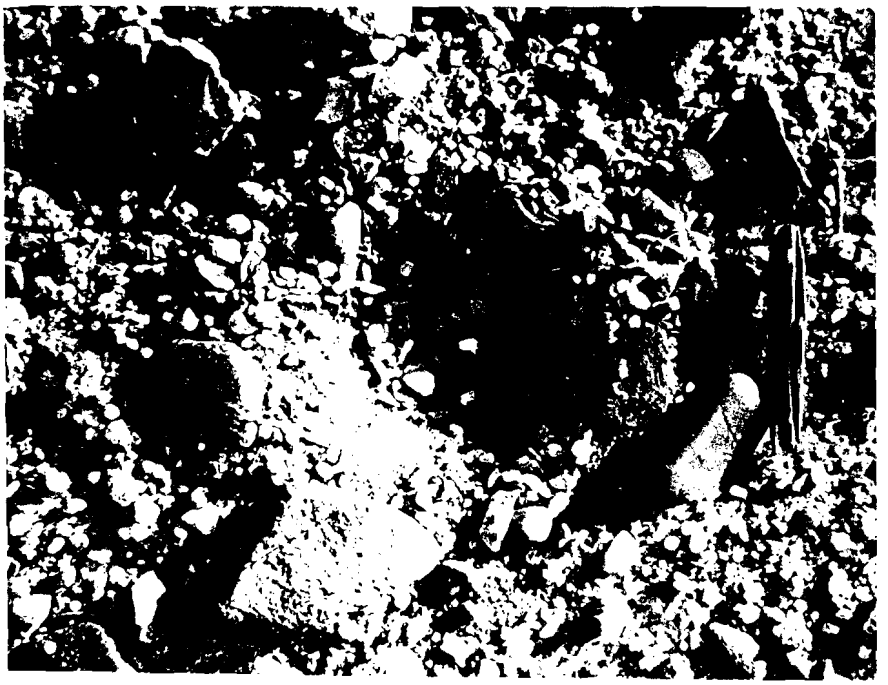


Fig. 20. Newly constructed Snowy Plover nest scrape in area D, on 16 June 1971, at Cheyenne Bottoms WMA.

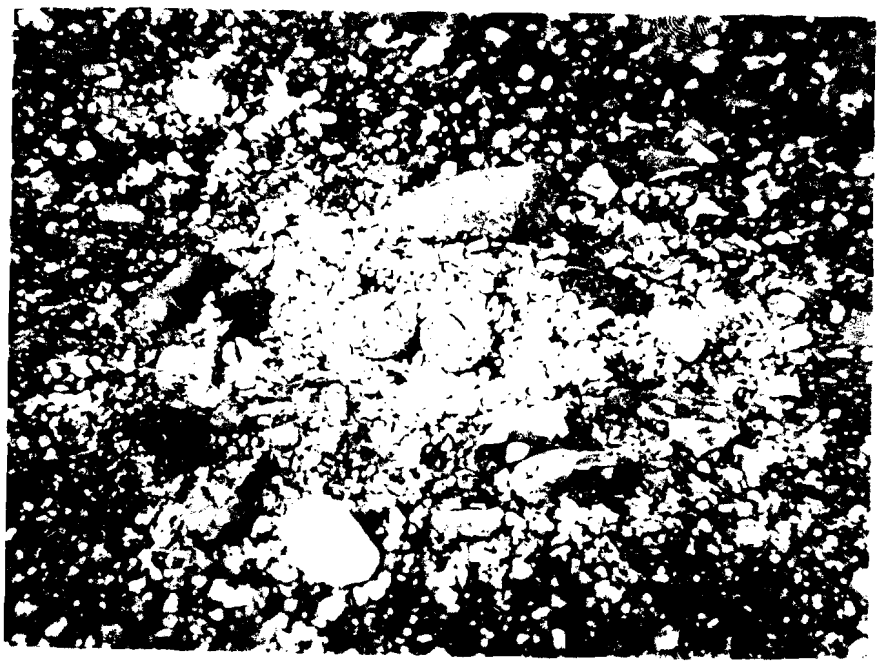


Fig. 21. The same Snowy Plover nest with two eggs, on 20 June 1971, at Cheyenne Bottoms WMA. This illustrated the addition of nesting material as the eggs were laid.

semipalmatus) by Palmer (1967), and the longer incubation periods of 27 days for the Killdeer (Davis 1943) and 26 to 30 days for the Piping Plover, with an average of 28.7 days (Wilcox 1939).

Schwinn (1964) stated that the fledging period for the Snowy Plover was 28 days. In the present study, it was confirmed that birds fledged in 28 days. Considering that Snowy Plover eggs were laid every other day, that the incubation period was 26 days, and that the fledging period was 28 days, I have shown in Figure 22 the span covering the period of egg laying through fledging for nine nests in 1970 and 18 nests in 1971. The span from egg laying through fledging was considered as 58 days in each case. Egg laying commenced as early as 22 April and as late as 26 June. This indicated a total span of 124 days for the breeding season. It is interesting to compare this lengthy breeding season of 124 days to that of 58 days for the arctic-breeding White-rumped Sandpiper (Calidris fuscicollis) reported by Parmelee et al. (1968).

Observations began on 23 June 1970, which did not include any earlier nests. The average date at which egg laying commenced in 1971 was 4 June. One-third of the 54 eggs laid during the 1971 season were laid in a one week span from 12 through 18 June. These dates closely compare to the breeding records of Parmelee et al. (1969). Sutton (1967) noted the early arrival date of 20 March in Oklahoma for the Snowy Plover, and also earlier nesting records. On 13 May 1961 two recently hatched chicks were noted by Sutton. This would place the laying of the first egg on about 12 April. The majority of

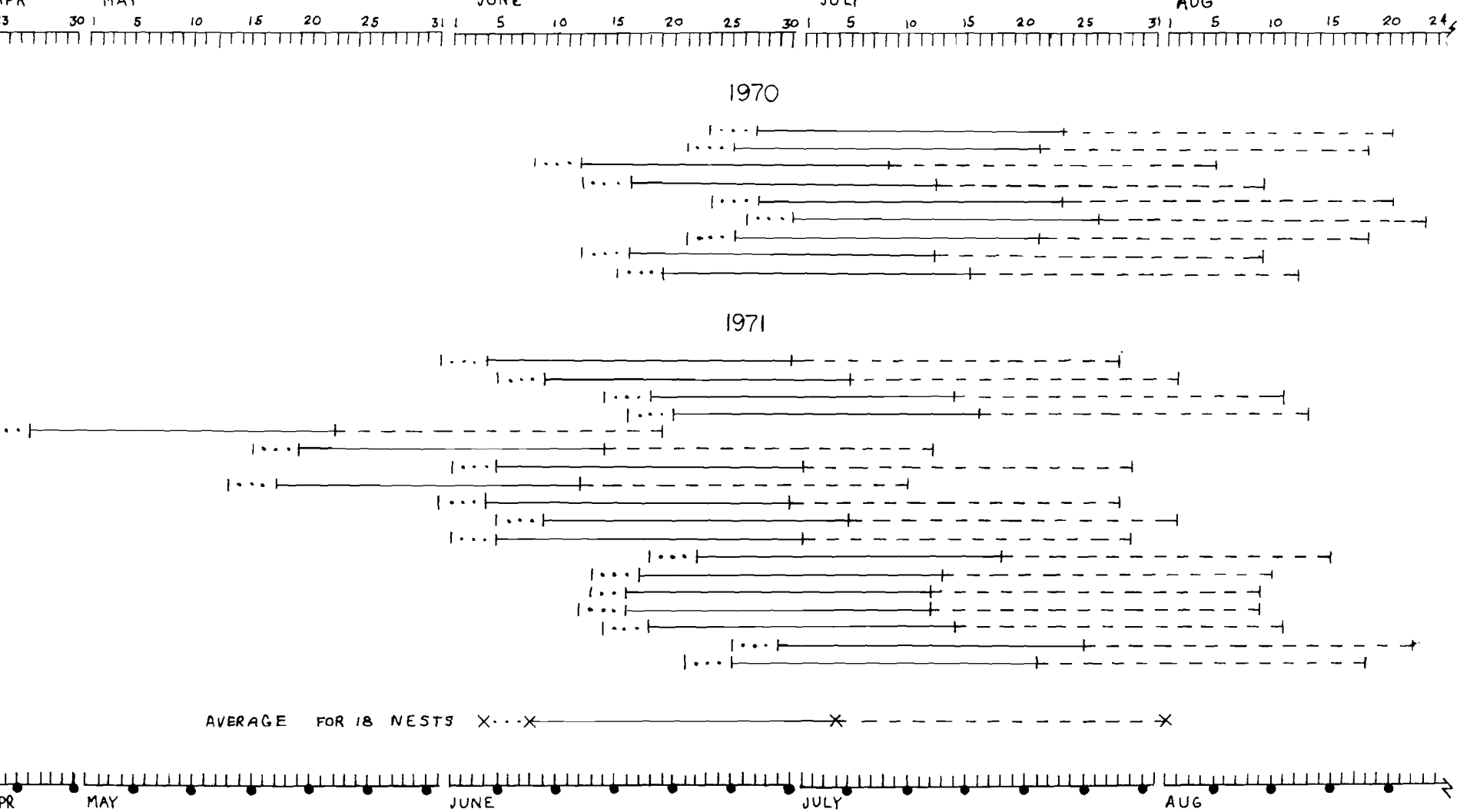


Fig. 22. Chart showing the time span of the egg laying period (dotted line), incubation period (solid line), and fledging period (dashed line) for nine Snowy Plover nests in 1970, and 18 nests observed in 1971. The average of all 18 nests in 1971 is marked by "X".

nests in Oklahoma were probably started in mid-May.

The male and female both shared in the duties of incubation, but there appeared to be great irregularity in the amount of participation by each. Zimmerman (1951), Walters (1954), and Rittinghaus (1956, 1961) felt that the female was on the nest during most of the day with few interruptions. The male was believed to be on the nest from between 1700 and 1900 hours until around sunrise the following morning. None of the three observers was able to make observations at night and only speculated upon the activity.

Use of the apparatus described on page 9 to record the activities of three nests for a total of 11 days produced various results. It was found, with only a few exceptions, that the female incubated throughout the day, only pausing to chase off intruders or to feed briefly. The male remained on the nest for one to one and one-half hours in the evening, beginning between 1700 and 1800 hours, and again for about the same amount of time between 0600 and 1000 hours. During this time the female was always observed feeding voraciously. On three specific occasions, it was determined that the female was on the nest throughout the night. On other nights, the sex of the incubator could not be positively determined.

Throughout the period that the female was on the nest, the male could be seen standing 20 to 30 m. away, preening or sleeping, or at other times feeding at the nearby water's edge. Aggressive behavior of the female towards the male was often

noted after I captured, banded, and released the female. If the male had gone to the nest to incubate the eggs during her absence, he was furiously chased out of the area when she returned. On two occasions when males were released after banding, they chased the female away from the nest, but in all other cases the male went immediately to the water and preened. Even though the role of the male during incubation seemed small, the female was unable to incubate the eggs successfully by herself. In one case, the male was not seen after 30 June 1970 and the female kept incubating for shorter periods each day, until she was last seen on the nest 6 July. Rittinghaus (1961) experienced the same situation, but noted that four days was the longest period that a "widowed" female continued to incubate.

During the heat of the day, 1300 to 1800 hours, the incubating bird often stood over the eggs, shading them from the sun, rather than sitting on the eggs (Fig. 23). Bailey and Niedrach (1965) observed an incubating adult Snowy Plover run into nearby water and return to a nest with wet breast feathers, but they were unable to ascertain whether the bird had intentionally wet its feathers and brood patch to help cool itself and its eggs. During this study, three Snowy Plovers and two Killdeer were captured on their nests while incubating when the air temperature was between 95 and 103°F. All five of these birds were dripping with water on the brood patch and on all of the breast feathers. This substantiated the observations of Bailey and Niedrach. Since all of the nests were 40 to 100 m. from water, wetting of the feathers

Fig. 23. Snowy Plover shading egg during the heat of the day, on 24 June 1970, at Cheyenne Bottoms WMA.

could not have been accidental. In several other nests, the eggs were observed to have upon them salt deposits, presumably due to the evaporation of the salty water used by the incubating adults.

The change-over of incubating birds always occurred with a definite ceremony, which decreased in intensity with time (Rittinghaus 1956). As soon as the bird on the nest noticed its mate coming to relieve it, it began to transport debris to the edge of the nest. The nest bird then stood over the eggs while the relieving mate tossed some particles as it approached. Only then would the bird at the nest be replaced. As the incubation period progressed, these actions became symbolic head movements, even to the point of nodding gestures.

If the bird was frightened off the nest, transporting was not observed, but usually the bird tossed some debris at a few meters distance. The bird then continued, running in a crouched position, on a zigzag course away from, and to the flank, of the intruder. From a distance of approximately 20 m., the bird stopped and called a flute-like "peo-eet" ("too-eet" by Simmons, 1955) while standing erect. The bird then bobbed upwards, as though standing on tiptoes with the neck outstretched, and returned to its original position. If the intruder followed in pursuit, the bird ran, often to nearby cover, to hide, calling a slurred "trr-trr-drrp" (as interpreted by Simmons, 1955).

Armstrong (1947) wrote that distraction displays were the result of conflicting drives, one to protect the nest or young,

the other to flee from the intruder. Early in the period of incubation, the second drive was strongest and, as previously described, the bird readily left the nest as soon as an intruder was observed in the area. As incubation progressed, the drive to protect the nest increased in intensity, thus causing a type of injury-feigning referred to as the "mobile lure-display." This was described for the Snowy Plover by Simmons (1951) and for the Ringed Plover by Williamson (1947). In this study, the display was first observed only four to five days prior to hatching and was performed by either parent. As the bird left the nest, it ran in a crouched position for approximately 20 m. or farther, and spread its tail, displaying the white outer tail feathers and white flank, while beating its extended wings on the ground (Fig. 24).

False brooding occurred with increasing stages of intensity and usually followed stages of the mobile lure-display. False brooding was observed as the bird partially concealed itself behind clumps of grass or a large stick. The bird settled down on the ground as though preparing to incubate a clutch of eggs. With increased intensity, the wings were raised and lowered, and the tail was fanned.

Hatching

The eggs at nine nests were visibly cracked at two to four days prior to hatching, but were not pipped earlier than four to five hours before hatching. Pipping occurred 18 hours before

Fig. 24. Posture of the adult performing the "mobile lure-display." (Taken from R. A. Richardson in Simmons, 1951.)

hatching in the Killdeer (Davis 1943) and the Mountain Plover (Laun 1957). Wilcox (1939) found the eggs of the Piping Plover to be pipped four days before hatching. Possibly he was referring to the visible cracking, rather than an actual opening in the shell. Welty (1963) stated that a chick hammered at its shell with its egg tooth for one or two days before pipping. This action would explain the cracking several days prior to actually breaking through the shell. Rittinghaus (1961) heard this tapping as early as 70 hours before hatching. The tapping could be heard by placing the egg to one's ear. In the present study, this tapping was heard at eleven nests. At one nest the tapping sound was heard as early as 84 hours prior to hatching. The chicks, however, were not known to peep before hatching, as described by Davis (1943) for the Killdeer.

Rittinghaus (1961) noted that it is possible for the young to hatch at any hour of the day, but most of the chicks hatched at night, between 1700 and 0900, in this study. Two chicks, in each of seven nests, hatched within four hours of each other. Two of these were in the early afternoon, the remaining five were between 1700 and 2100 hours. The third egg in six of these nests hatched from six hours to as long as 24 hours after the first two chicks. From seven nests, the average time from the hatching of the first chick to the last was 14 hours. The length of the period between hatching of the first and last egg suggested that the onset of incubation varied and could begin as early as the laying of the second egg or not until the third egg was laid.

There was no relation found between the order of egg laying and the order of hatching, as the eggs in four nests each hatched in a different order.

Empty shells were immediately removed from the nest by the adult. This was attributed to the highly selective value in protecting the young from predators that would detect the conspicuous shells (Parmelee et al., 1968). Shells were found from 10 to 70 m. from the nest.

Immediately after the chick emerged from the shell, its down was wet and matted (Fig. 25). The down dried and was fluffy within one to two hours after the chick hatched. If the nest was not disturbed, the parents did not lead the chicks away until all of the eggs in the nest had hatched and the chicks were dry. At four nests which were under close observation and were visited frequently during hatching, each chick was led away from the nest as soon as it could stand. To coax the chicks into leaving the nest, the parents ran up to the nest, often brooded the chicks briefly, then ran off a short distance, and gave a continuous, quick "pip-pip-pip..." After the chicks were led from the nest, they were brooded by the male while the female returned to the nest to incubate any unhatched eggs.

The nesting success for both seasons is shown in Table IV. Of the 20 nests observed in 1970, there were 12 successful nests, totaling 31 chicks. There were 22 eggs which did not hatch. One egg from each of two different nests was infertile. Two eggs in

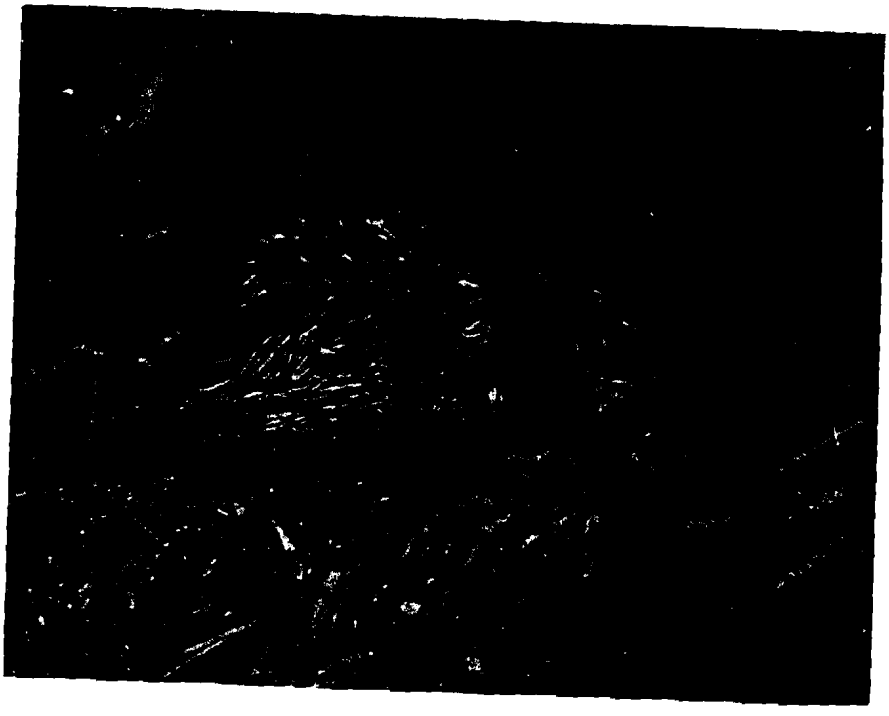


Fig. 25. Freshly hatched Snowy Plover chick at 0900 hours, on 16 July, at Cheyenne Bottoms WMA.

TABLE IV. The number of successful and unsuccessful nests in 1970 and 1971 at Cheyenne Bottoms WMA.

	1970	1971	Total
Successful nests	12	15	27
Number of eggs hatched	31	39	70
Number of eggs not hatched	3	3	6
Unsuccessful nests	8	12	20
Number of eggs	22	32	54
Total eggs	53	71	124
Percent successful	58.5	54.9	56.5

one nest contained developed embryos but did not hatch, while the third egg in this nest did hatch. Three nests of two, two, and three eggs each were destroyed by a predator which was believed to be a raccoon since the eggs had been carefully opened and the contents removed. One nest of two eggs and one nest of one egg was abandoned. Three nests containing three eggs each were reported to have been destroyed by hail (Schwilling, personal communication).

There were 27 nests observed in 1971, with 39 chicks from 15 successful nests. Thirty-two eggs did not hatch. One egg was determined to be infertile. One egg in each of two different nests was pipped but did not hatch. Two nests of three eggs each were destroyed by cattle stepping on the nests. One nest of three eggs was believed to have been destroyed by a coyote by reason of the nearby tracks, method of eating the eggs, and seeing a coyote in the immediate area. Three nests containing three eggs each and one nest containing two eggs were destroyed by hail. Three nests of one egg each and two nests of three eggs each were abandoned.

Renesting

There were no cases of double-brooding. It would seem highly unlikely that double-brooding would occur since both parents tend the young and since one bird alone was not able to incubate successfully. Rittinghaus (1961), also, did not find evidence of double-brooding.

Snowy Plovers, renested, however, when the nest was destroyed. In four cases of renesting, only one female (112-152901) renested with the same male. This pair renested 10 m. from the first nest. Both of these nests were destroyed by cattle stepping on the nests. In mid-August, the same female was observed tending an unbanded juvenile, indicating a third nest. Rittinghaus (1961) noted that he never experienced a second renesting.

On the evening of 11 June 1971, there was a hail storm. The next day, three adult nesting females from area C were seen in area D. It was later confirmed that two of the nests were destroyed by the storm, while the third had been destroyed by cattle, as previously mentioned. Two of these females (F901 and F904) were each seen with a new male. On 18 June, F904 was found on a nest with three eggs. These eggs hatched 14 July, and by using the method described for Figure 22, it was determined that the first egg was laid on 14 June, only two days after first seeing the bird at the nest location. The bird (F904) had not been seen on the first nest in area C since 10 June, and perhaps the nest was abandoned then, prior to being destroyed. This would allow four days for establishing the second nest. The first mate of F904 was seen alive 28 July in Pool #4.

On 13 June 1971, three eggs hatched in area C and the chicks were banded. There was a storm shortly after they had been banded, and the next morning two of the chicks (911 and 913) were found just barely alive, plastered down in the mud,

only able to move their heads. The third chick appeared to be uninjured. The first two chicks (911 and 913) were removed from the nest. The third chick (912) was tended by the male and female for two days, at which time it was believed to have died as a result of exposure during the storm. The female (101-116834) was seen in area D on 17 June with a new male. A nest was not found until 11 July, and all three eggs hatched 21 July. This would place the first egg as being laid on 21 June, four days after F834 was first seen in area D.

The third female (F907) seen on 12 June after the hail storm, was seen several more times in the area, but no nest was found. Her mate was seen by himself several times in August and was believed not to have renested.

Care, Dispersal, and Development of the Young

The young left the nest within hours after they hatched. In 1970, a nest was closely observed as the eggs hatched. Each chick was led from the nest from one to one and one-half hours after hatching. The female was usually the bird that brooded the eggs or chicks in the nest, but the male also brooded the chicks in the nest on several occasions. Several males that would not come under the trap to incubate were caught later when the chicks had hatched and were retained under the cage.

During this study, a total of 134 birds were banded

(Table V). Of this total, 54 adults and eight juveniles were color banded, color marked, or both. Observations on the dispersal of the young were based on this marking technique.

When chicks were found on the breeding grounds, both the male and female were usually closeby. The male, however, was in the immediate vicinity a greater percentage of time than the female. The birds were seen together as a family group, rather than separated, as suggested for the Mountain Plover by William G. Smith (Bent 1929). Wilcox (1939) noted that the Piping Plover chicks remained within a short distance of where they hatched. The farthest distance that Wilcox recorded for a chick was 400 feet from the nest site. This was also the case with the Snowy Plover when available feeding sites were close. In cases where feeding sites were not close, the chicks were capable of traveling a great distance without food or water. In the 1970 breeding season, Pools #3 and #4 had been drained. By the time the chicks hatched, the only remaining water was two small pools in Pools #3 and #4 at the intersection of Pool #1, #3, and #4. The birds in area A had to travel between 300 and 600 m. to water, but this did not present a problem. The birds in area B, however, had just slightly over 2 miles to travel to the nearest water. The first of three nests in this area to hatch was on 12 July. These birds were also seen in area B on 14 July. The next day, the eggs in the second nest in this area hatched. The following day, these chicks and adults were still in area B.

TABLE V. The number of Snowy Plovers banded during the 1970 and 1971 breeding season at Cheyenne Bottoms WMA.

	1970	1971	Total
Adult birds banded			
Captured on nests: Males	3	11	14
Females	14	13	27
Captured in mist nets: Females	...	6	6
	17	30	47
Juveniles banded			
Known age	12	31	43
Unknown age	30	14	44
	42	45	87
Total birds banded	59	75	134

The female of the third nest, yet to hatch, was seen in one of the pools at the previously mentioned intersection on 16 July. On 17 July a group of four or more chicks was seen near one of these pools. As I approached, they were led into the nearby tall grass by the male of the second nest. Only one of these chicks was found and identified as the chick of the first nest. Shortly after, the female of the second nest, and the male and female of the first nest were also in the vicinity. Further searching did not locate any additional chicks. On 21 July the last nest in area B hatched. Two days later, the male was seen at the pools but no young was seen with him. On 28 July, 13 days after hatching, two young and their parents of the second nest were identified together at the pool. Throughout the season, the only juveniles found were around these small pools. Even though one case of grouping more than one family together was noted, this was not a common practice.

During the 1971 breeding season, nesting areas C and D had feeding areas relatively closeby and family groups were observed to be concentrated around these areas. Area B was once again isolated, but Pool #4 did not dry completely, thus allowing the family groups from that area to remain too far out in the pool to be easily observed.

One family group, which was identified as being from area B, was located shortly after fledging in the same area of concentration as in 1970. In area D, one clutch moved one and one-quarter miles eastward to water, rather than one-quarter mile south. This was

believed to have been because of high, dense grass rather than a deep canal between the nest and the nearer water to the south. On three occasions chicks less than 10 days of age were observed to swim in deep water to avoid capture. The move was made in a maximum of three days and was probably accomplished in a shorter length of time. There were five nests in area D that were within 400 m. of two small pools, each 30 by 50 m. in size. Four of these clutches were observed around these pools until the chicks fledged. The fifth family group went the opposite direction, 800 m. to a larger pool.

Development of the young was studied by raising two chicks from the age of two days until 31 days of age. Table VI compares the wing lengths of 911 and 913 with other known-age birds recaptured in the field. Measurements were made from the wrist to the tip of the last primary when the wing was held against the body. Figure 26 illustrates the wing growth of three birds. Table VII compares the weight gains, in grams, of 911 and 913 to the average weight gain measured by Schwinn (1964) on eight birds that he raised. Also, one known-age bird was weighed in the field. Figure 27 illustrates this comparison of weight gains in Snowy Plover young.

As previously mentioned, 911 and 913 were found plastered into the mud after a heavy rain. They had been in this condition overnight and were extremely weak and unable to hold up their heads. The two chicks were placed in a small brooder with artificial light and were force-fed meal worms for the first one and one-half

TABLE VI. Wing lengths of Snowy Plover juveniles at Cheyenne Bottoms WMA, 1970 and 1971.

Age (in days)	112 152911	913	941	915	945	946	959	924	101 116824	844
1	12	11	10	...	...	...	...	...	9	...
2	14	14	...	9	12	13	12	10	...	...
4	14	14	...	...	...	...	...	...	...	12
8	17	19	14	...	...	...	...	...	...	...
11	24	30	...	13	...	...	...	...	...	...
13	30	38	...	...	...	...	...	...	19	...
14	35	42	...	...	...	...	...	...	22	...
15	38	45	...	...	27	31	...	...	...	...
18	48	54	...	...	...	...	...	...	...	36
21	54	65	...	...	...	...	...	...	...	...
25	62	77	...	...	...	...	43	...	...	...
28	71	86	...	...	...	...	...	...	...	...
31	81	93	...	79	...	...	...	...	...	...
49	...	...	...	...	...	...	...	111	...	...

All measurements are in millimeters from the wrist to the tip of the primaries with the wing against the body.

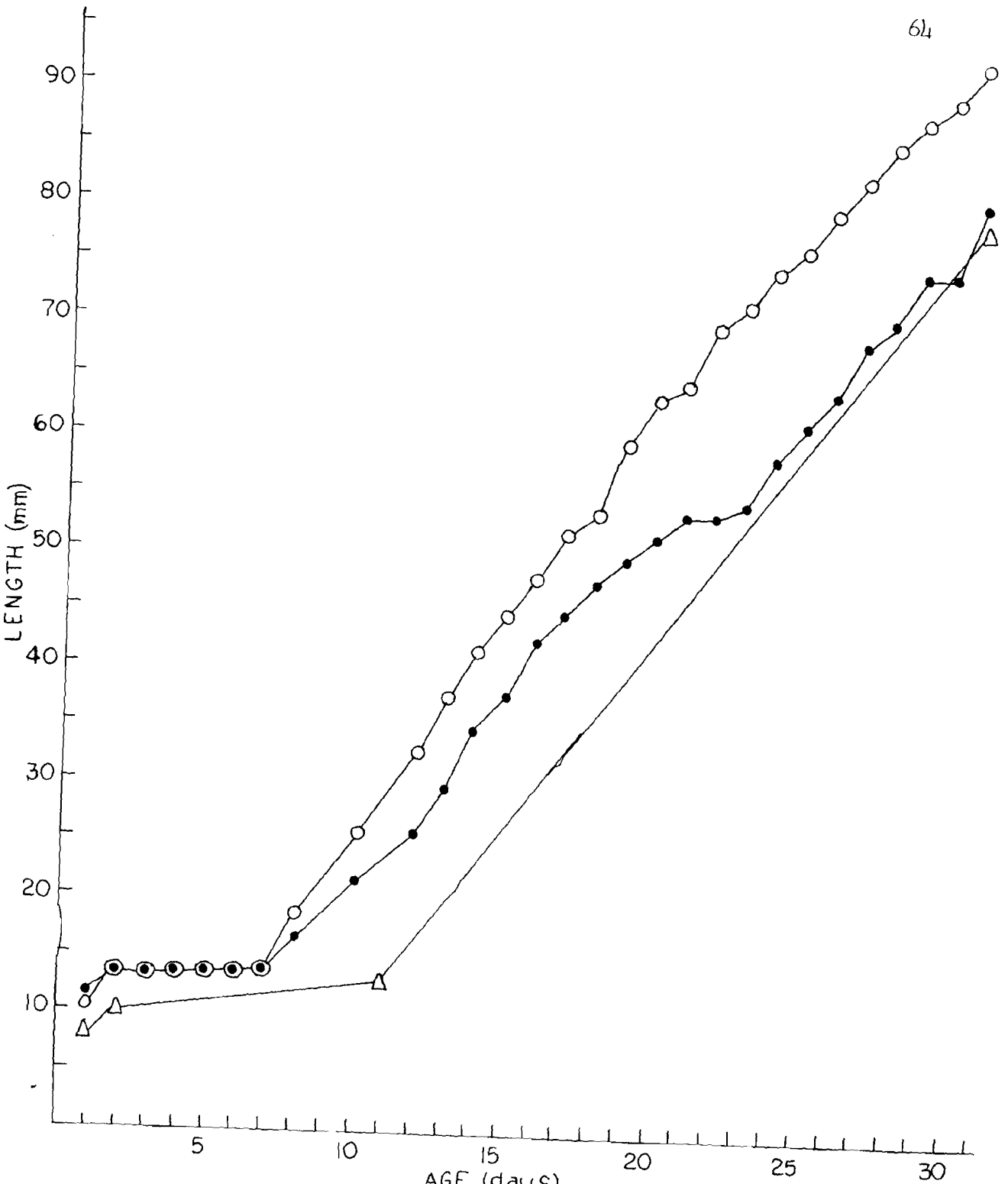


Fig. 26. Wing growth of Snowy Plover juveniles at Cheyenne Bottoms WMA, 1971. Measurements were made from the wrist to the tip of the primaries with the wing folded against the body. Birds 112-152911 (•) and 112-152913 (O) were raised in captivity. Bird 112-152915 (Δ) was banded when one days old, released, and recaptured three times.

TABLE VII. Weight gains of Snowy Plover juveniles at Cheyenne Bottoms WMA, 1971, compared to those raised by Schwinn[1].

Age (in days)	112 152911	112 152913	Schwinn	112 152915
2	6.1	6.6	5.8	...
4	7.7	8.2	6.6	...
6	9.0	10.1	8.3	...
8	10.2	11.8	9.6	...
10	12.4	15.6	12.5	...
12	14.3	17.8	14.0	...
14	16.9	20.5	17.3	...
16	17.0	21.9	20.0	...
18	18.	24.6	22.7	...
20	17.7	25.0	25.3	...
22	17.0	25.5	27.0	...
24	19.3	28.5	28.8	...
26	22.0	30.0	31.1	...
28	24.4	31.6	32.2	...
30	23.7	31.0	33.9	...
31	25.8	32.0	34.3	27.3
33	...	...	35.0	...

1 The average weight gain of eight Snowy Plovers raised by Schwinn (1964) Measurements are made in grams.

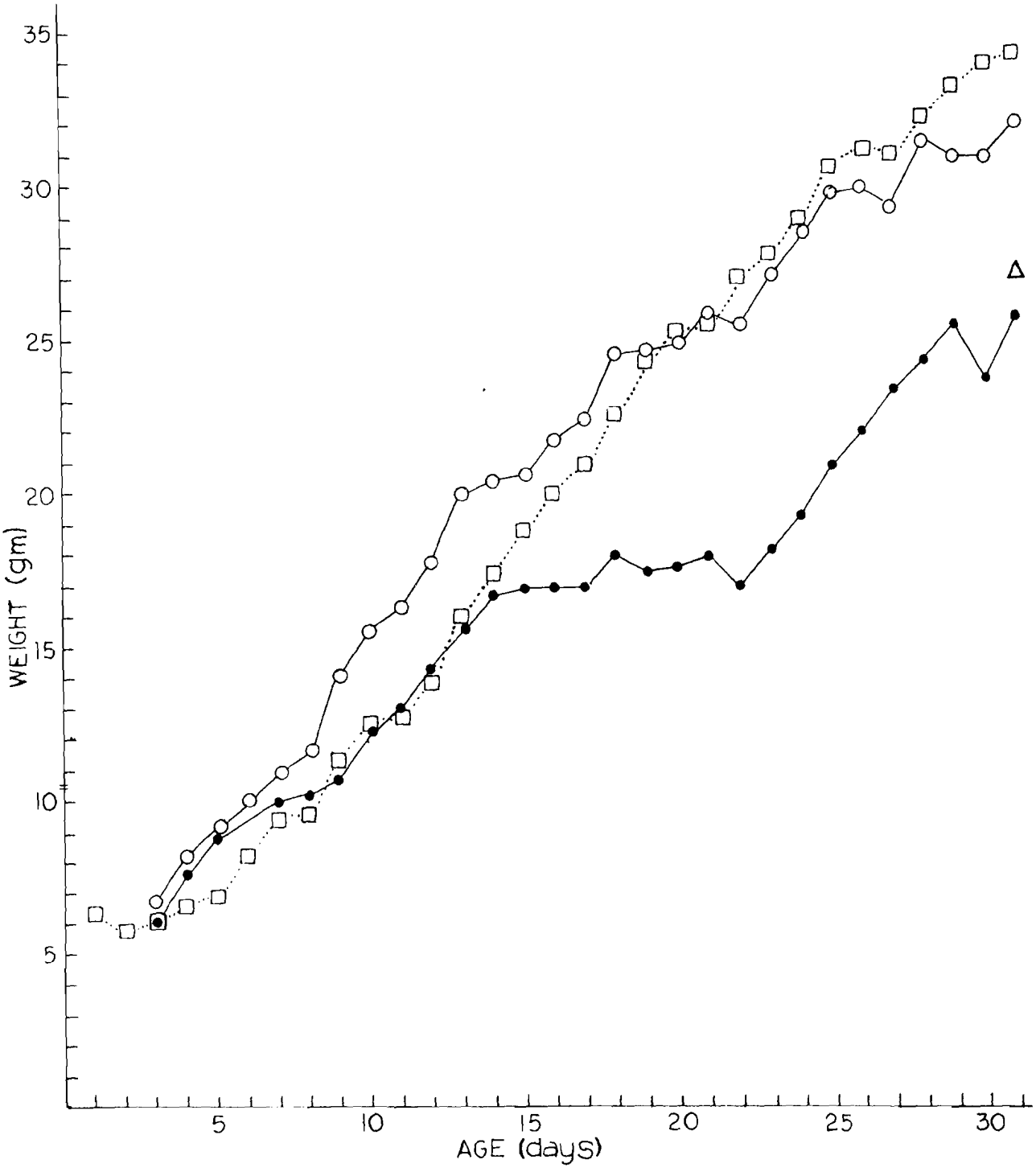


Fig. 27. Weight gains in Snowy Plover juveniles at Cheyenne Bottoms WMA, 1971. Birds 112-152911 (•) and 112-152913 (O) were raised in captivity. The single weight marked (Δ) was from bird 112-152915 as in Figure 26. An average weight gain in eight plovers raised in captivity by Schwinn (1964) is also plotted (□).

days. They were also given a diluted solution of Terramycin to help combat any disease induced by their prolonged exposure. Both were healthy and able to eat on their own when they were three days of age (Fig. 28). However, 911 had a relapse when six days of age and required constant attention. The chick finally recovered when about eleven days of age. Both birds were color banded and given nicknames of Orb, for an orange and blue band (911), and Rey, for a red and yellow band (913). These names were placed on the photographs and the chicks will be referred to by these names.

Description of the day-old Snowy Plover's upper parts were a pale buff or cream-buff mixed with a light gray. The crown, back, rump, and wings were distinctly spotted with brown and black. The under parts were pure white. There was a distinct white band encircling the neck and a black line behind the eye (Fig. 28 and 29).

Until the fourth day, only relative increases in overall size were observed, with the indication of pin feathers on the primary on the fourth day. The culmen measured eight millimeters. On the fifth and sixth day, there was an increase in the length of down and size of primaries, and the culmen measured nine mm. on both birds. On the seventh day, pin feathers were prominent on the primaries, secondaries, sides, scapulars, and upper back. The tenth primary pin feather measured three mm. on the eighth day, with other pin feathers also increasing in length, and an increase to 10 mm. on the culmen was noted. By the tenth day,

Fig. 28. Three-day-old Snowy Plover chick (112-152913) raised in captivity. The picture was taken on 15 June 1971 while the chick was feeding on water boatmen.

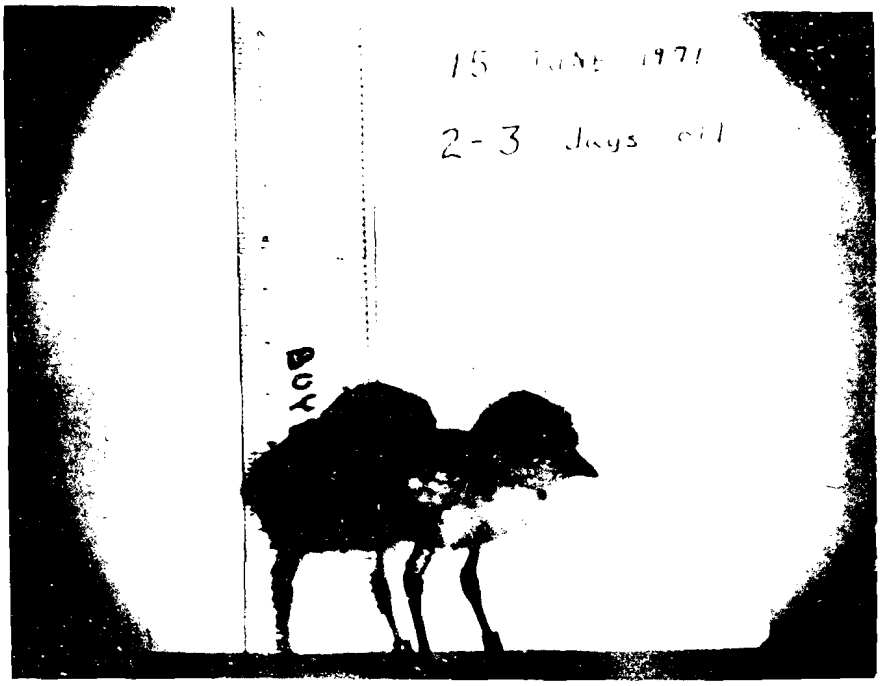


Fig. 29. Profile of three-day-old Snowy Plover.

Fig. 30. Profile of twelve-day-old Snowy Plovers. Orb on the left and Rey on the right. Feathers extended beyond sheath on the crown, scapulars, neck, and sides.

feathers were just breaking from the sheath, on the crown, scapulars, neck, and sides. Primary pin feathers had increased to seven mm. on the twelfth day (Fig. 30) and the culmen increased to 11 mm. From the thirteenth through the fifteenth days, the feathers developed greatly on the sides, scapulars, back, crown, and coverts. There was a marked difference in the two birds now. Orb was about one-half day behind Rey in development at this time. The tenth primary was out of the sheath seven mm., and the sides were nearly completed on the sixteenth day.

Until now, the main diet was meal worms and water boatmen. The faster the food moved, the more active the birds became. The water boatmen were placed in a pan of water in the brooder, as shown in Figure 28. Occasionally, crayfish up to 4 cm. long, minnows, mud dauber larva, and paralyzed spiders from mud dauber nests were fed to the chicks.

The chicks were placed during the day in a concrete box 1.3 m. square. About five cm. of water was maintained in parts of the box to hold minnows, and sand bars were constructed on the edges for the birds to stay on. The birds ran into the shallow areas, which were only one cm. deep, and caught water boatmen and minnows. Already at this age, they ran in short bursts of speed, stopped briefly, and then ran with another short burst of speed, as is the manner of the adults. Their feeding habit of attacking sideways was also an adult characteristic.

During days 17, 18, and 19, the primaries developed to 22 mm.

The primary and secondary coverts and breast feathers were 13 mm. The rectrices were appearing beyond the sheath, but still had downy tips. The contour of the head was becoming smoother and rounded. Pin feathers were appearing around the ear and bill. In comparing Figures 31 and 32, difference in wing development between the two birds can be noticed.

At 23 days of age, Rey had developed greatly, with primaries 34 mm. long. The tail was 24 mm.; the crown, around the bill, and the ear patch were nearly complete, as were the breast and sides. Orb had suffered another slump and was not advancing in development much, as his primaries were 26 mm. and the tail 17 mm. Figures 33 and 34 show the profile of the two chicks at 25 days of age. It can be noticed that Rey was about 90 mm. tall where as Orb was only 80 mm. A difference of feather development can also be noted in the photographs of their extended wings in Figures 35 and 36. At this date, the primaries measured 42 mm. on Rey and 28 mm. on Orb. Also on this date, I began feeding the birds Plains Killifish (Fundulus kansae) which were 25 to 40 mm. long. These fish were easily obtained in the shallow pools. On the first day, Rey and Orb each ate 75 fish. The next day, they both ate 30 killifish in a timed period of 140 minutes.

Schwinn (1964) considered the Snowy Plover juveniles to be fledged at the age of 28 days. Rittinghaus (1961) stated that the fledging periods were about six weeks, with an average of 41 days. The Ringed Plover was said to fledge in 21 to 23

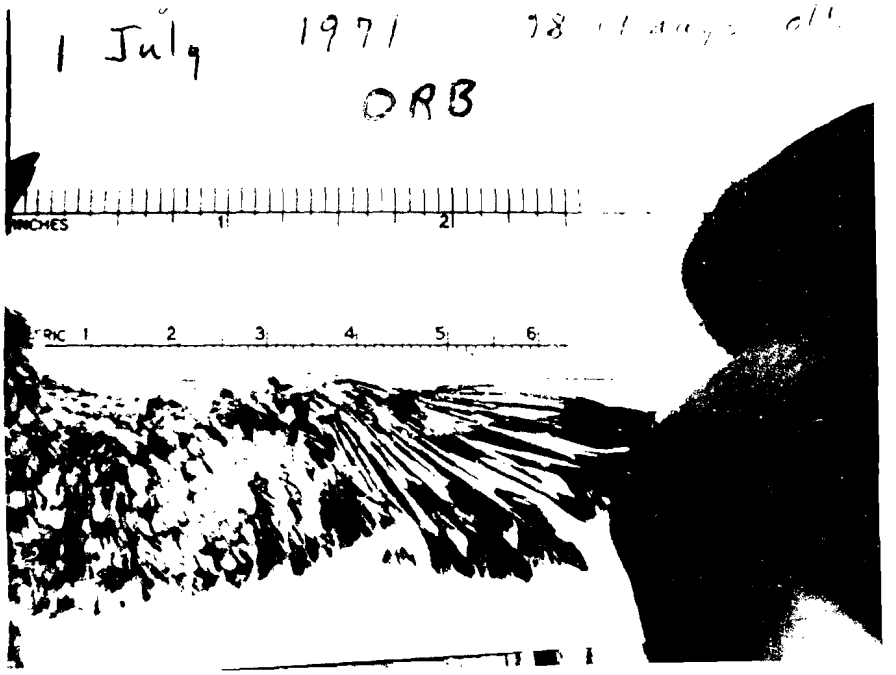


Fig. 31. Feather development on wing of Orb at 19 days of age. Tenth primary extended beyon the sheath 14 mm. Primary coverts extended 13 mm.

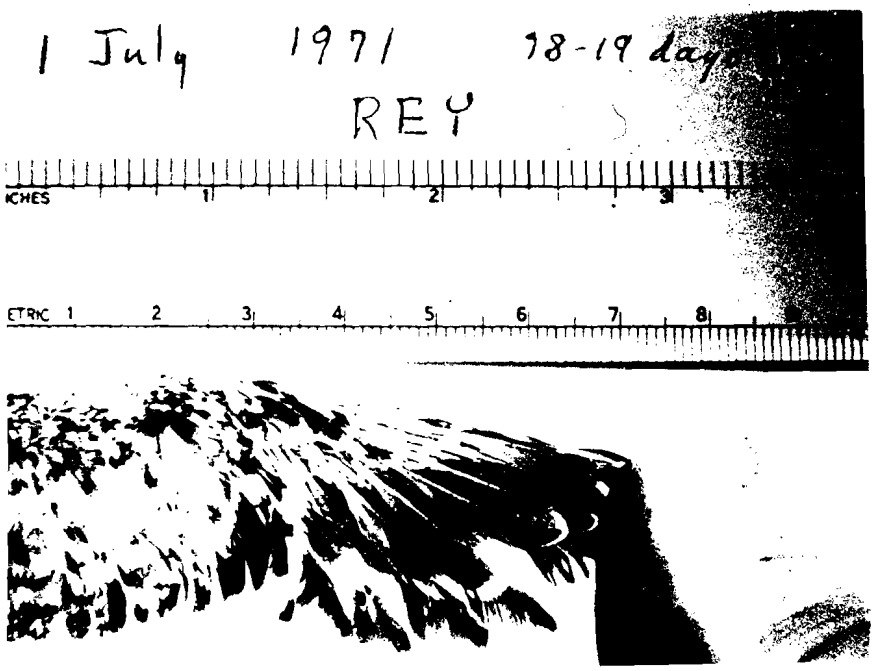


Fig. 32. Feather development of Rey at 19 days of age. Tenth primary extended beyond the sheath 16 mm. Primary coverts extended 21 mm.

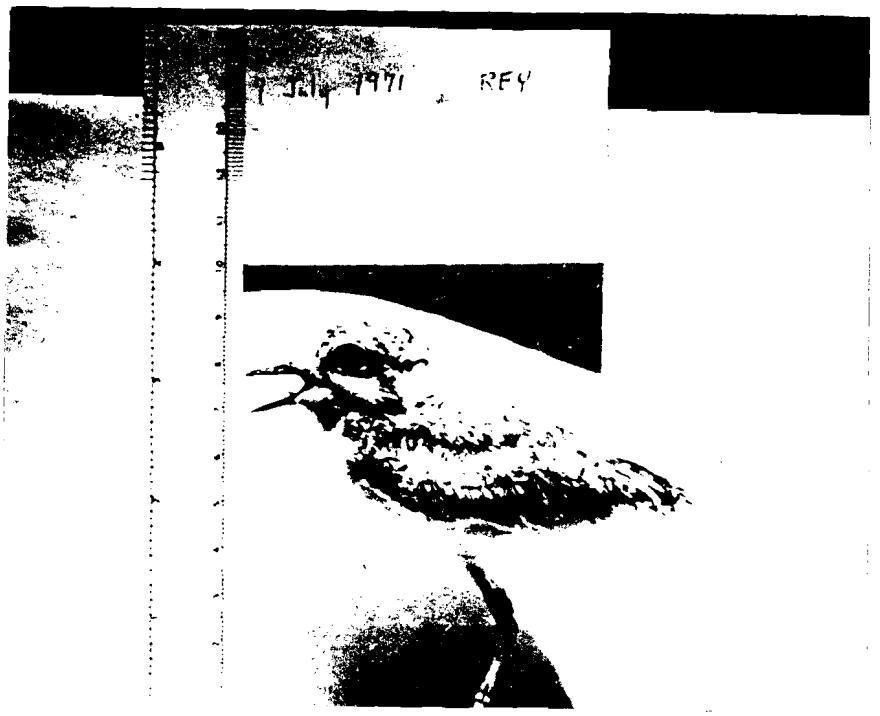


Fig. 33. Profile of Rey at 25 days of age. Rectrices measured 28 mm.

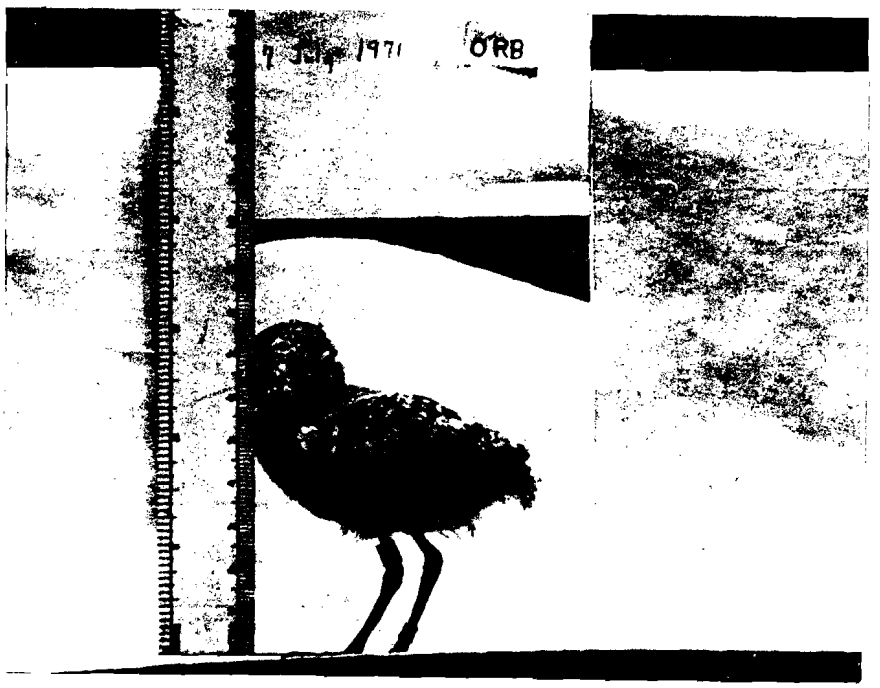


Fig. 34. Profile of Orb at 25 days of age. Considerably more down than Rey and smaller in size. Rectrices measured 22mm.

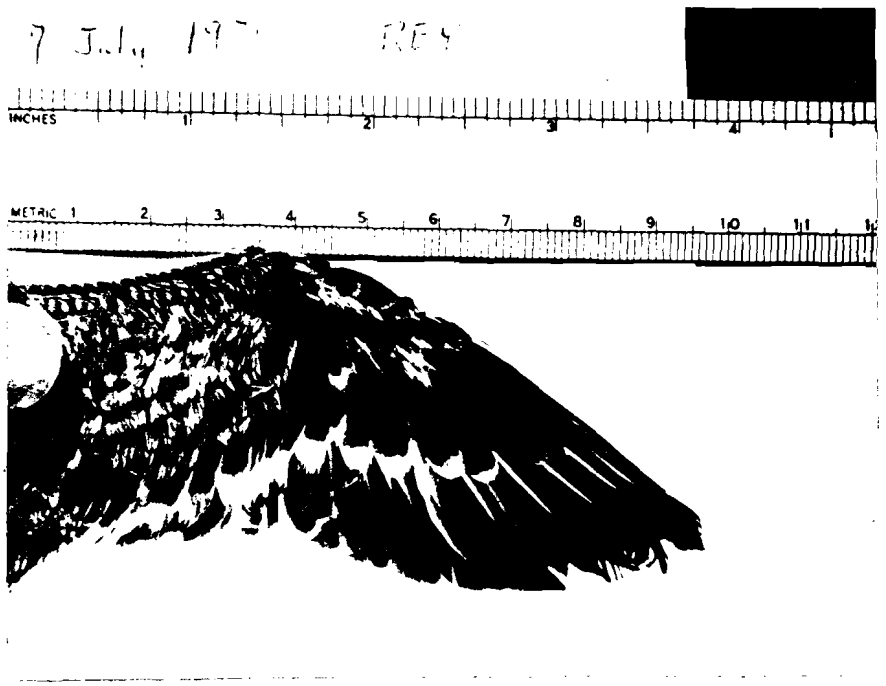


Fig. 35. Feather development on wing of Rey at 25 days of age. Primaries measured 32 mm and primary coverts, 31 mm.

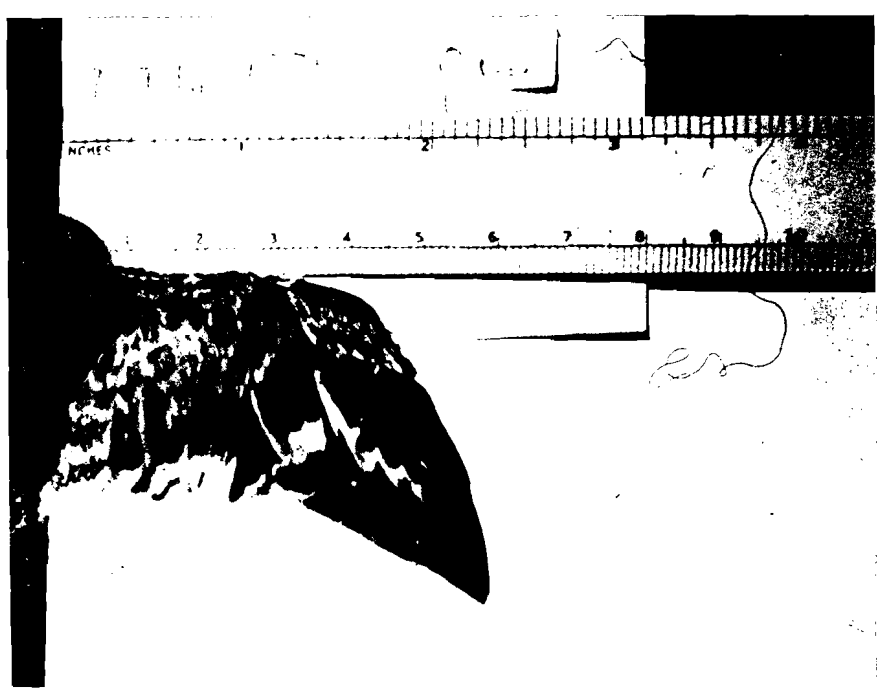


Fig. 36. Feather development of wing on Orb at 25 days of age. Primaries measured 28 mm and primary coverts, 24 mm.

days (Laven 1940), and Wilcox (1939) reported the fledging period for the Piping Plover was 30 to 35 days.

Rey was able to fly short distances and was considered to be fledged when 28 days of age. The primaries were 50 mm., secondaries 31 mm., and rectrices 34 mm. long. The crown, forehead, around the culmen, ear patch, back, scapulars, breast, sides, and wing coverts were considered complete. Orb had progressed greatly, but was not as far along as Rey. The primaries were 37 mm., secondaries 27 mm., and rectrices 23 mm. The crown, scapulars, breast, sides, and wing coverts were complete. Figure 37 shows both birds when they were 28 days of age.

The birds were released in area D, 14 July 1971, when they were 31 days of age. Figures 38 and 39 compare the profiles, and Figures 40 and 41 compare the wing development, of both birds prior to being released. As can be noted, both birds still had down on the back of the neck and rectrices. Rey was capable of sustained flight that afternoon, but Orb was not able to fly even short distances until 32 days of age. Rey was not seen during the day in the area where they were released; however, he was seen there with Orb and a female at 2100 hours. Rey and the female were not seen during the next day, but all three were seen together in the area where they were released at 1930 hours. Orb was seen in this area for the next 11 days. Rey was not seen until 4 August 1971, which was 21 days from the time of release. At this time, he was seen in

Fig. 37. Orb (l.) and Rey (r.) huddled together in the sun in the concrete box at 28 days of age. Note difference in size.

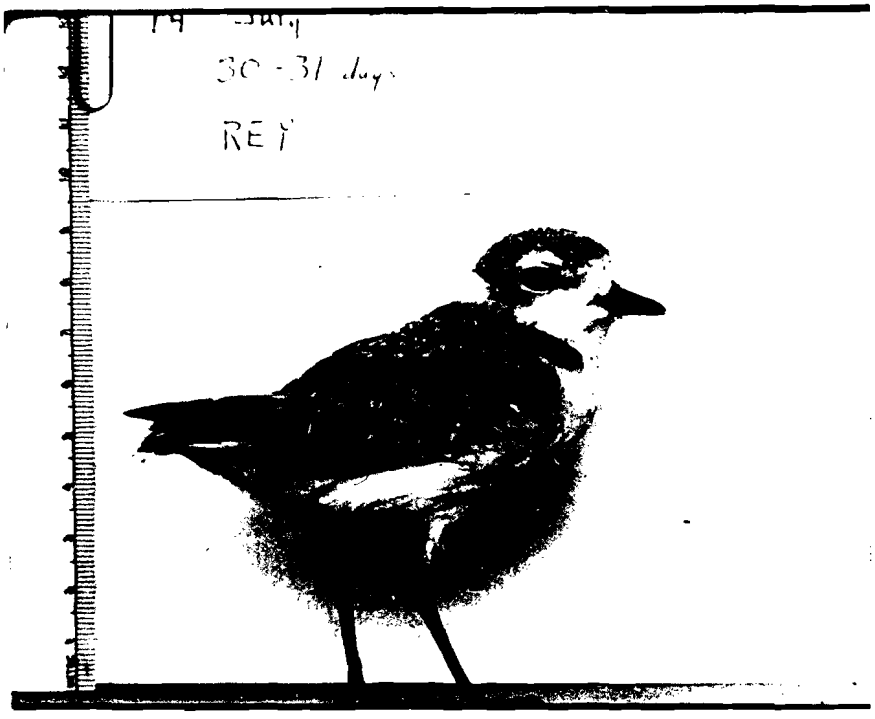


Fig. 38. Profile of Rey prior to release when 31 days of age. Down remained only on back of neck and tip of rectrices.

Fig. 39. Profile of Orb prior to release when 31 days of age. Down still remained on crown, cheeks, neck, and rectrices.

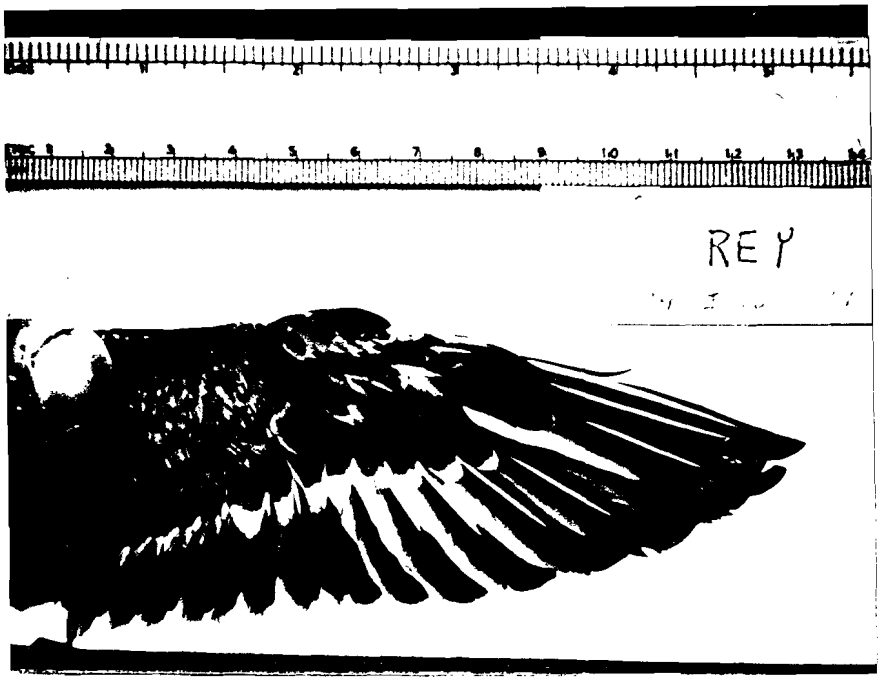


Fig. 40. Feather development on wing of Rey at 31 days of age. Primary measured 56 mm. Total wing measured 93 mm.

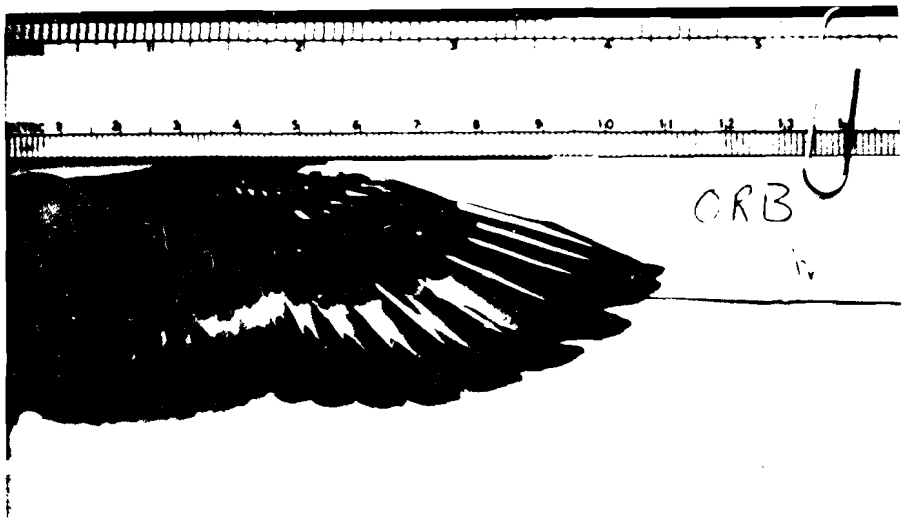


Fig. 41. Feather development on wing of Orb at 31 days of age. Primary measured 46 mm. Total wing measured 81 mm.

Pool #3, across the Bottoms from area D. On 18 August 1971, both birds were again together and were seen in Pool #4. Rey was next seen in Pool #2 on 20 August 1971, at which time Orb was still in Pool #4. Both were in Pool #2 on 22 August 1971 through 24 August 1971, at which time I concluded observations of the study area.

Departure from the Breeding Ground

As early as 25 July 1971, unmarked birds were observed in the area and were believed not to have nested in the area. Five such birds were mist netted, and only two of these birds were seen at a later date. This would indicate that these birds moved out of the area after remaining only a short time.

Prior to my departure from the study area on 24 August 1971, a group of 21 Snowy Plovers was observed. Of these, eight were identified as to individual birds, six others were banded, and five adults and two juveniles were not banded. On 4 September 1971, there were 17 birds observed in area D. There were four family groups identified and only one fledged juvenile was unbanded. Snowy Plovers were last seen in the area 25 September 1971.

On 4 September 1970, two birds that were banded as siblings on 22 July 1970 in Pool #4, were recaptured together by Edmund Martinez on the west edge of Pool #2. Ten Snowy Plovers were seen 10 October 1970, which is the latest recorded date for the Bottoms.

From the evidence shown, it can be inferred that the family groups remain together until fledged, perhaps even during migration. Additional research on the movement of wintering populations is necessary to ascertain how long family groups remain together and whether the birds remain paired throughout the winter. Clarification of early pairing courtships needs to be done.

The Snowy Plover was recently placed on The Blue List (American Birds, 1971). This is an "early warning system" for birds which are experiencing population declines due to chemicals or reduction of habitat. Further study of the bird in all of its breeding and wintering grounds is essential to finding a means of releasing those pressures now being applied upon the Snowy Plover populations.

SUMMARY

Research on the breeding biology of the Snowy Plover was conducted at Cheyenne Bottoms Waterfowl Management Area, Barton County, Kansas, from 23 June to 30 July 1970, and from 25 May to 24 August 1971.

Emphasis was placed upon three phases of the breeding cycle: (1) nest construction and courtship, (2) the role of the sexes in care of the eggs and young, and (3) growth, development, and dispersal of the young.

Breeding birds generally arrived during the first week of April. The earliest nest was 24 April 1971 and the latest was started 26 June 1970.

Males were determined by the presence of darker plumage behind the eye and on the forehead. Selection of the nest site was by the male. Courtship and copulation were observed.

Twenty nests were located in 1970, and 27 nests were found in 1971. The total number of successful nests was 27, or 56.5 per cent. The maximum clutch size was three eggs. The average size of 38 eggs was 31.7 x 23.1 mm.

Incubation usually began with the completion of the clutch. Both sexes incubated, with the female having the greater amount of attentiveness. The incubation period for eight clutches varied from 24 to 26 days, with an average of 25.5 days.

Renesting occurred when the eggs were destroyed or the young

perished within a few days of hatching.

The period between the hatching of the first and last egg varied from six to 24 hours. The average for seven nests was 14 hours. Shells were removed immediately after hatching.

Fifty-four adults and eight juveniles were color marked and color banded to aid in determining movements of birds throughout the breeding season. A total of 134 birds was banded during the study.

Both adults tended the young, but the male was with the young a greater percentage of the time. Family groups remained intact, even after fledging. The young were considered fledged as early as 28 days, with some taking up to 32 days.

Two chicks were raised in captivity. Various measurements of their development were made daily. These data were compared to known-age chicks in the field.

The adult and juvenile Snowy Plovers began flocking together in early August. The largest flock, 22 birds, was seen on 24 August 1971. Some of these birds were still in the area 4 September 1971. The latest fall date for the area was 4 October 1970.

Literature Cited

LITERATURE CITED

Announcing The Blue List: an "early warning system" for birds. 1971. (Author anonymous). American Birds. 25(6):948-949.

A. O. U. Committee Report. 1957. Check-list of North American birds. Amer. Ornith. Union, Baltimore. xiii, 691pp.

Armstrong, Edward A. 1947. Bird display and behavior. Lindsay Drummond Ltd., London. 431pp.

Bailey, Alfred M. and Robert J. Niedrach. 1965. The birds of Colorado, Vol. 1. Denver Museum of Nat. Hist. 454pp.

Bent, Arthur Cleveland. 1929. Life histories of North American shore birds, Part II. U. S. Nat. Mus. Bull. 146, 412pp.

Bradbury, W. C. 1918. Notes on the nesting of the Mountain Plover. Condor. 20:157-163.

Davis, Emma. 1943. A study of wild and hand reared Killdeers. Auk. 61(2):223-233.

Howes, Cecil. 1950. This month in Kansas history: the largest lake in Kansas. The Kansas Teacher. 58(6):38-40.

Jehl, Joseph R., Jr. 1968. Relationships in the Charadrii (shorebirds): a taxonomic study based on color patterns of the downy chicks. Memoir San Diego Soc. Nat. Hist. 3:1-54.

Jencks, Hugh. 1953. The Cheyenne Bottoms. Kansas Fish and Game. 10(4):6-8.

Laun, H. Charles. 1957. A life history study of the Mountain Plover (Eupoda Montana Towsend) on the Laramie Plains, Albany Co., Wyoming. Unpublished Thesis, Biology Department, University of Wyoming, Laramie.

Laven, H. 1940. Beiträge zur Biologie des Sandregenpfeifers (Charadrius hiaticula L.). Journal für Ornithologie. 88:183-287.

Mühlenberg, Michael. 1961. Begattungsversuch eines Seeregenpfeifers (Charadrius alexandrinus) an einem Stein. Vogelwelt. 82:26-28.

Palmer, Ralph S. [illegible]e descriptions and species accounts. In Gardner [illegible]), Peter Matthiessen, and Robert Verity Cl[illegible]irds of North America. The Viking Press, N. [illegible]

Parmelee, D. F. [illegible]ner, and W. D. Graul. 1968. Summer schedule [illegible] biology of the White-rumped Sandpiper in the c[illegible]an Arctic. Wilson Bull. 80:5-29.

_____, M. D. [illegible], and H. A. Stephens. 1969. Charadri[illegible]s of Cheyenne Bottoms, Part I. Kan. Orn. Soc. [illegible] 20(2):9-13.

Pickwell, Gayle. 1925. The nesting of the Killdeer. Auk. 42(4):485-496.

RCA Linear Integrated Circuits. 1967. Technical Series IC-41, Radio Corp. of Amer., Harrison, New Jersey.

Rittinghaus, H. 1956. Untersuchungen am Seeregenpfeifer (Charadrius alexandrinus L.) auf der Insel Oldeoog. J. Orn. 97:117-155.

_____. 1961. Der Seeregenpfeifer. Die Neue Brehm-Bücherei. A. Ziemsen Verlag, Wittenberg, Lutherstadt. 126pp.

Schoewe, Walter H. 1949. The geography of Kansas, Part III, hydrogeography. Trans. Kans. Acad. Sci. 56(2):131-190.

Schwinn, Myron. 1964. Raising shorebirds in captivity. Unpublished Research Problem, Biology Department, Kansas State Teachers College, Emporia.

Simmons, K. E. L. 1951. Distraction-display in the Kentish Plover. British Birds. 44(6):181-187.

_____. 1955. The significance of voice in the behaviour of the Little Ringed and Kentish Plovers. British Birds. 48:106-114.

Sutton, George Miksch. 1967. Oklahoma birds. University of Oklahoma Press, Norman. 674pp.

Walters, J. 1954. Der Brutanteil Geschlechter beim Seeregenpfeifer (Leucopolius alexandrinus L.). Limosa. 27:19-24.

Welty, Joel Carl. 1963. The life of birds. Alfred A. Knopf, N. Y. 546pp.

Wilcox, LeRoy. 1939. Notes on the life history of the Piping Plover. Birds of Long Island. 1:3-13.

Wilcox, [illegible]enty year banding study of the Piping
Pl[illegible]-152.

Willia[illegible] distraction-display of the Ringed
Pl[illegible]iaticula). Ibis. 89:511-513.

Zimmer[illegible] Brutbiologie des Seeregenpfeifers
([illegible]ndrinus L.). Ornithologische
[illegible]0-273.