A PRELIMINARY STUDY OF THE INTERIOR LEAST TERN (STERNA ALBIFRONS ATHALASSOS BURLEIGH AND LOWERY)

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A PRELIMINARY STUDY OF THE INTERIOR LEAST TERN (STERNA ANTILLARUM ATHALASSOS BONAPARTE AND LOWERY)

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INTRODUCTION

Perhaps the most challenging issue facing the author preliminary to launching this study was the desire to select a relatively "unexplored" topic. In addition, because of other duties it was necessary to select for study a species which nested comparatively late in the season. The interior least tern (Sterna albifrons athalassos Burleigh and Lowery) was, thus, an appropriate choice, since its habits were not well known, and it is characteristically a late breeder, usually not beginning the nesting season until mid-June or afterwards.

Although much has been written concerning the life histories of terns, proportionally few extensive studies have been conducted on the least tern. Of the larger studies, only the work of the Marples (1934) on British terns (dealing primarily with the common tern) contains extensive data on the least tern. The other investigations are far over-balanced in favor of a few of the larger more common species. This may be partially explained by the fact that the least tern colonies are smaller in comparison to terneries of other species. In addition, the nests are usually well scattered within the breeding grounds so that study of a large group of birds from one blind is not nearly so practicable.

The literature on the least tern consists primarily of short articles. The most notable of these include the studies of Hagar (1937) on the least tern of the Atlantic coast of Massachusetts, the summary by Bent (1947), the investigations of Ganier (1930) on the Mississippi River in Tennessee, and the work of Stiles (1939) with birds of the Missouri River in Iowa. The articles by Ganier and Stiles represent the most extensive studies of the interior subspecies, since both present information on the principle phases in the life history. With a few exceptions,

viz., the investigations of Moser (1940) and Youngworth (1930), the remaining published information on the inland birds consists of short notes, principally on migration with occasional references to observations of breeding.

The present investigation was divided into three parts: (1) An actual field study of a colony of interior least terns at Bell Island in the Ohio River from June 20 to early September, 1953; (2) an analysis of available information in published literature; and (3) correspondence with ornithologists throughout the range of the subspecies. The latter in particular aided in supplementing published data, in gaining the most recent information on the birds, and in presenting as well rounded a picture of the interior least tern as was possible in the limited time.

ACKNOWLEDGEMENTS

The writer wishes to express his sincere thanks to Dr. George J. Wallace, who supervised this study and whose constant guidance in the preparation of the manuscript has been of great help. Grateful acknowledgement is also due to Richard Brewer and Kenneth Stewart of Southern Illinois University who assisted the observer in much of his field work, to Dr. S. G. Bergquist for assistance in preparation of the section on sandbar formation, and to Dr. C. L. Gilly and Dr. R. H. Manville for suggestions in preparing the final manuscript.

The writer also wishes to express deep gratitude to the following persons who, through personal correspondence with the author or with Richard Brewer, provided a wealth of unpublished data on the interior least tern that would have otherwise been unavailable: Richard Anderson, St. Louis, Missouri; Frank Baumgartner, Oklahoma A. & M. College; Ben B. Coffey Jr., Memphis, Tennessee; James E. Comfort, St. Louis, Missouri; Miss Doris Gates, North Platte, Nebraska; Karl H. Maslowski, Cincinnati, Ohio; Robert M. Mengel, University of Kansas; Burt L. Monroe, Anchorage, Kentucky; Russell Mumford, Cortland, Indiana; H. R. Smith, Evanston, Illinois; M. G. Vaiden, Rosedale, Mississippi; Dr. Gordon Wilson, Western Kentucky State Teacher's College; Dr. Roy S. Wycoff, Lexington, Nebraska; and William Youngworth, Sioux City, Iowa.

TAXONOMY OF THE NORTH AMERICAN LEAST TERNS

The family Laridae is one of the 16 living families of the order Charadriiformes. It comprises 85 species and 185 subspecies and contains two subfamilies, Larinae, the gulls, and Sterninae, the terns, both world-wide in distribution. The great majority of the Sterninae are inhabitants of coastal areas of the seas; however, a few species occur on the larger fresh-water lakes and streams.

The least tern (Sterna albifrons) is divided into 9 subspecies by Peters (1934), but two new Mexican races and the interior race athalassos have been described since that time. The species is found throughout most of the world in temperate and tropical regions, along the coasts and in the interior. The nominate race albifrons is found in western Asia and Europe south to the Mediterranean Sea. Of the five North American forms three occur in the United States. They are antillarum, athalassos and browni. All except athalassos inhabit sea coasts, at least during the breeding season.

In early taxonomic studies the breeding least terns of the Mississippi River and its tributary streams were considered identical to those of the coastal waters of the United States. Mearns (1916) separated the California Pacific coast birds as a new race browni. Oberholser (1938) assigned specimens from northern and central Louisiana to that race, even though this presented the unusual case of two populations of a subspecies separated by over a thousand miles of land area.

In 1942 Burleigh and Lowery described a new race of the least tern from the interior United States based on specimens collected in Louisiana and additional material from the Mississippi and its tributaries to the north. They designated it Sterna albifrons athalassos, the interior

least tern. It supposedly differs from antillarum, the Atlantic and Gulf coast race, in the much darker coloration of the upperparts, and in having little distinction between the color of the back and the hind neck.

It is the opinion among some workers that the diagnostic features of the three northern races of this tern are much too superficial and variable to warrant their taxonomic separation. Such characteristics as number of black primaries, used to separate browni of the Pacific coast and black on the bill, used to separate staebleri of Mexico, are known to exhibit much variation in all races. The black tip on the bill in particular seems to vary much with the season of the year in all races, being prominent during the breeding period and fading greatly by autumn.

Regardless of the problems involved in the taxonomy of these subspecies and the possibility that athalassos may not actually be a valid race, the fact remains that ecologically at any rate, the interior bird is distinctly different from the other North American subspecies. It is hoped that this study of the habits and environmental requirements of the interior least tern will reveal some information bearing on the validity of the race.

METHODS OF STUDY

Field work on the interior least tern consisted primarily of direct observation of selected groups of nests within the colony from a blind. The selection of a few nests rather than a large number was the only method practicable, since least tern nests are characteristically widely scattered within the boundaries of the ternery. The blind was first placed within a semi-circle of seven nests, and later moved to a second group of three. These were the most closely observed birds from which most of the data on breeding habits were taken. Tern nests to be studied were marked with small stakes and each assigned a letter so that it might be easily referred to in the notes.

The drop trap method of capturing common terns described by Palmer (1941) and Austin (1938) was not successful with the least tern. In almost every case the alarmed bird scurried under the edge of the trap before taking flight. One individual alighted on top of it and tried to reach the eggs by pecking at the wire (see Figure 1). Continued attempts at trapping caused the birds to become so wary that it was feared the normal routine of the ternery might be seriously disrupted. Austin (1934, 1947) experienced similar difficulties with common terns. Often birds would not return to the nest until the trap was removed. In the present study only one tern was captured by this method. The beginning of hatching, which greatly decreases the efficiency of trapping, since the young are precocial, necessitated termination of these activities.

The value of marking adults in this study would have been to observe the roles of the parents in nesting duties. Some such data were taken from observations of the one marked bird and its mate and from careful watching of other terns. Behavior traits when used with caution, were

useful in separation of males and females.

Frequently birds and nests other than those specifically under observation provided pertinent data. Thus, a general watch was kept over the whole colony from the blind and by walking through the ternery.

It had been planned to collect a limited number of specimens, but delay in securing permits prevented this.

Young terns were color banded so that their individual records could be kept. Weights were taken with a gram scale, accurate to the nearest gram. Measurements were taken in millimeters of total length, culmen, and wing. As feathers began to emerge their growth was also measured. Notes were kept on progression of the plumage.

Information on food habits was gathered by stomach analysis, observation of occasional discarded fish, and seining of the littoral waters.

The island and the ternery were mapped, and general records were kept on weather conditions, including temperature, wind direction, and velocity, the latter by estimate. Data on rainfall and river stages were secured from the official state observer at Shawneetown, Illinois, and from the United States Weather Bureau at Evansville, Indiana.

The extensive personal correspondence with many ornithologists throughout the Mississippi River Valley and adjoining areas was begun in early October, 1953, after completion of the field work. Through this method much information on variations in migration, environmental conditions, and breeding habits was made available.

Figure 1. An interior least tern attempting to reach her eggs through a wire trap placed over the nest.

DISTRIBUTION

General Range

The interior least tern ranges in summer from Baton Rouge, Louisiana, north along the Mississippi River and its main tributaries, the Ohio and Missouri, to southeastern Indiana, central Missouri, southeastern South Dakota, southeastern Wyoming, western Kansas, and western Oklahoma (panhandle area). Formerly, at least it occurred north in the Mississippi River Valley to northcentral Iowa, and rarely to eastern Iowa (Dubuque) and on the Missouri River system to Montana.

A more detailed account of its distribution is presented in the following discussion.

Spring Migration

Least terns appear in migration in large numbers along the Gulf coast of Louisiana in late April and early May. By the third week in April, the interior form has begun migration up the Mississippi River. Ganier (1930) considers the species common and well distributed in migration at Vicksburg, Mississippi, occurring in flocks of from 50 to 60 birds, which feed along the sloughs and the river. According to Mabbett (1890) birds first arrive at Rodney, Mississippi, between May 6 and 13. Vaiden [1] has observed least terns at Rosedale, Mississippi, as early as April 23 (1927), April 27 (1948), and May 8 (1934), but states that it is usually after May 10 when the first birds are noted.

Migration also occurs up the Red River at least as far as Shreveport in northwestern Louisiana, but for some reason seems to be much delayed

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[1] Citing of an authority without bibliographic reference means data were obtained by personal correspondence.

compared to movement up the main stream route. Jeter has observed least terns at this locality for several years and has never recorded their arrival before May 6 (1951, 4 birds). The following data depict the migration of the least tern at Wallace Dam on the Red River south of Shreveport as recorded by Jeter.

Date	Number
May 9	0 *
May 16	7
May 17	30
May 23	2
May 30	0

* one bird was seen north of the city on May 10.

Terns have been reported by April 30 (1939) near Bowling Green, Kentucky (Wilson), but the main migration apparently takes place in this region in mid-May. Maslowski considers the species to be reasonably common at Reelfoot Lake, Tennessee, in migration during the latter part of May. The writer has also observed the species here in late May. However, it is probable that many of the birds seen on the lake are resident on the nearby Mississippi River.

Migration of least terns does not occur regularly eastward from the Mississippi River, but at the only area on the Ohio River where they are known to breed - the Bell Island ternery near Shawneetown, Illinois - Brewer observed birds feeding on the river on May 25, 1953. Further upstream the species can be considered only as an occasional visitor in spring, though Mumford observed a flock of 17 birds on June 3, 1950, at the Hovey Lake Game Preserve, Posey County, Indiana (about 15 miles north of the Bell Island ternery). These were either migrating birds or a resident group from a ternery still undiscovered on the nearby Ohio

River.

From the area near the junction of the Ohio and Mississippi Rivers northward and westward to Nebraska and Iowa few migration records are available. The birds are usually seen near St. Louis, Missouri, but generally not until June (Comfort and Brewer). At Springfield, Illinois, terns are occasionally seen in migration during April (Pettingill, 1951). This early date is difficult to explain. Dr. T. E. Musselman at Quincy, Illinois, on the Mississippi River has never recorded the least tern there in over 40 years of observation (Smith and Brewer). This is in direct correlation with river conditions above St. Louis, Missouri, which are not favorable for nesting terns.

So far as is known, no regular migration occurs further north along the Mississippi River than its junction with the Missouri River, though records show that this has not always been the case (see summer distribution). The movement of the terns swings westward, following the course of the Arkansas River into Oklahoma and Kansas and the Missouri and Platte Rivers into southern Iowa, South Dakota, and Nebraska (to extreme southeastern Wyoming).

In Oklahoma, terns are usually seen in migration during the last week in May. Wetmore (1918) observed terns along the South Canadian River on May 24 and 26, 1905. Baumgartner gives a very early April 11 (1948) record for Payne County, and May 22 (1951) for Greer County (recorded by Brummett). Nice (1931) provides a May 14 date from Cleveland County.

Many migration records exist for Nebraska. The following data are representative dates from a 25-year summary of bird migration in that state (Anonymous, 1953). The stations listed are in order from east to

west.

Lincoln	May 4, 1926	May 30, 1930
Hastings	May 8, 1948	May 30, 1930
North Platte	April 18, 1947	May 26, 1949
Brule	June 12, 1948	June 20, 1947

With the exception of April records at North Platte, (in line with the April record for Oklahoma mentioned above) the general trend is from early May to June across the state. These early arrival dates could be the result of a regular cross-country migration, which enables individuals to traverse the distance to the regions in less time than those birds which follow the winding course of the rivers. It is also possible that vagrant birds stray ahead of the main flocks. Where field observations without collecting are involved, there is also the possibility of misidentification.

Near Omaha, Nebraska, on the Missouri River, least terns have been observed in migration by May 14 (1941) and as late as June 9 (1928) (Anonymous, 1953). In Iowa, Youngworth (1933) has observed the least tern at Sioux City as early as May 19 (1929); however, on the basis of over 75 records he states that in most years arrival varies between May 20 and June 1.

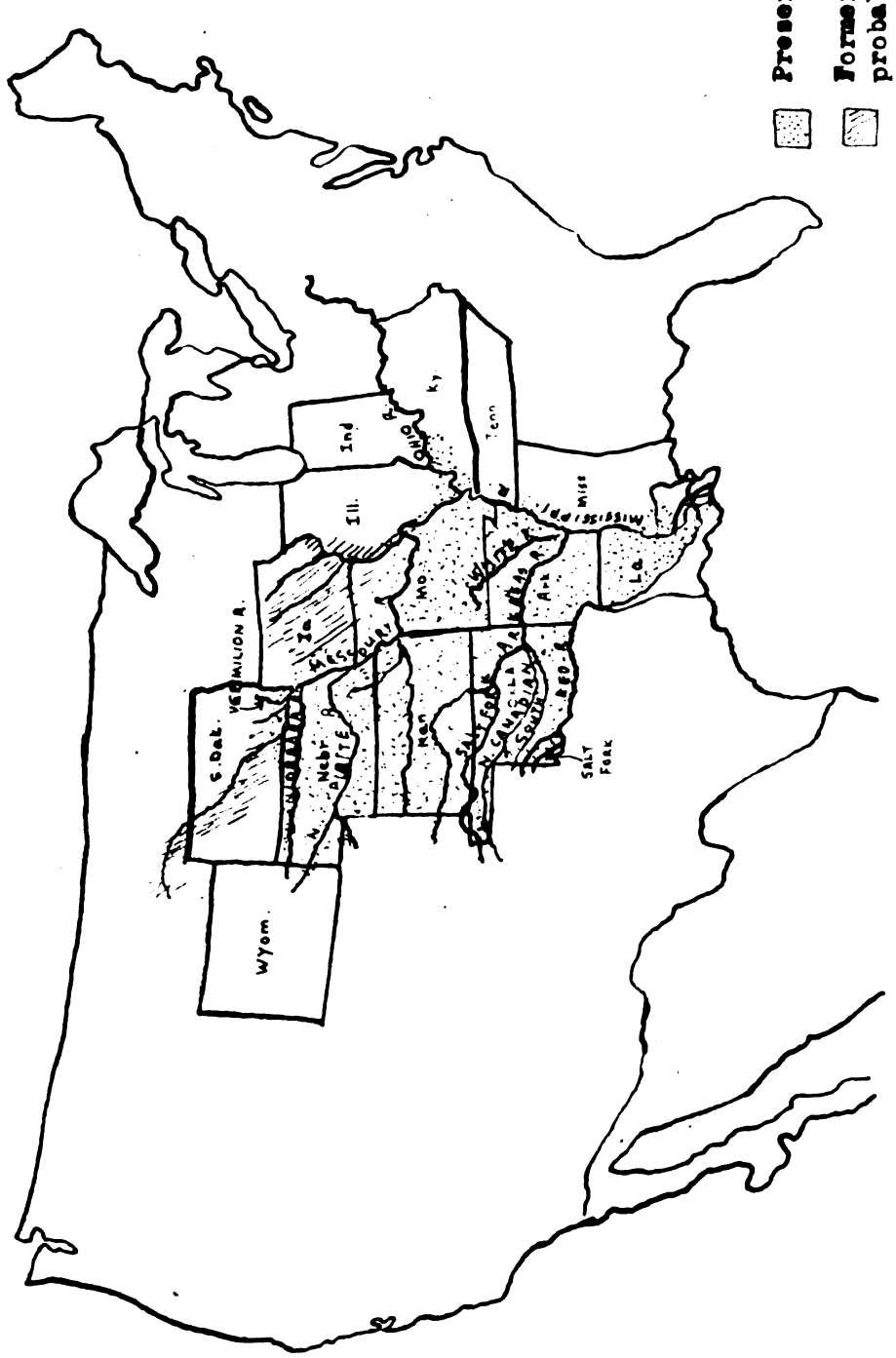

Figure 2. Summer distribution of the interior least tern. The rivers shown are those on which terns nest.

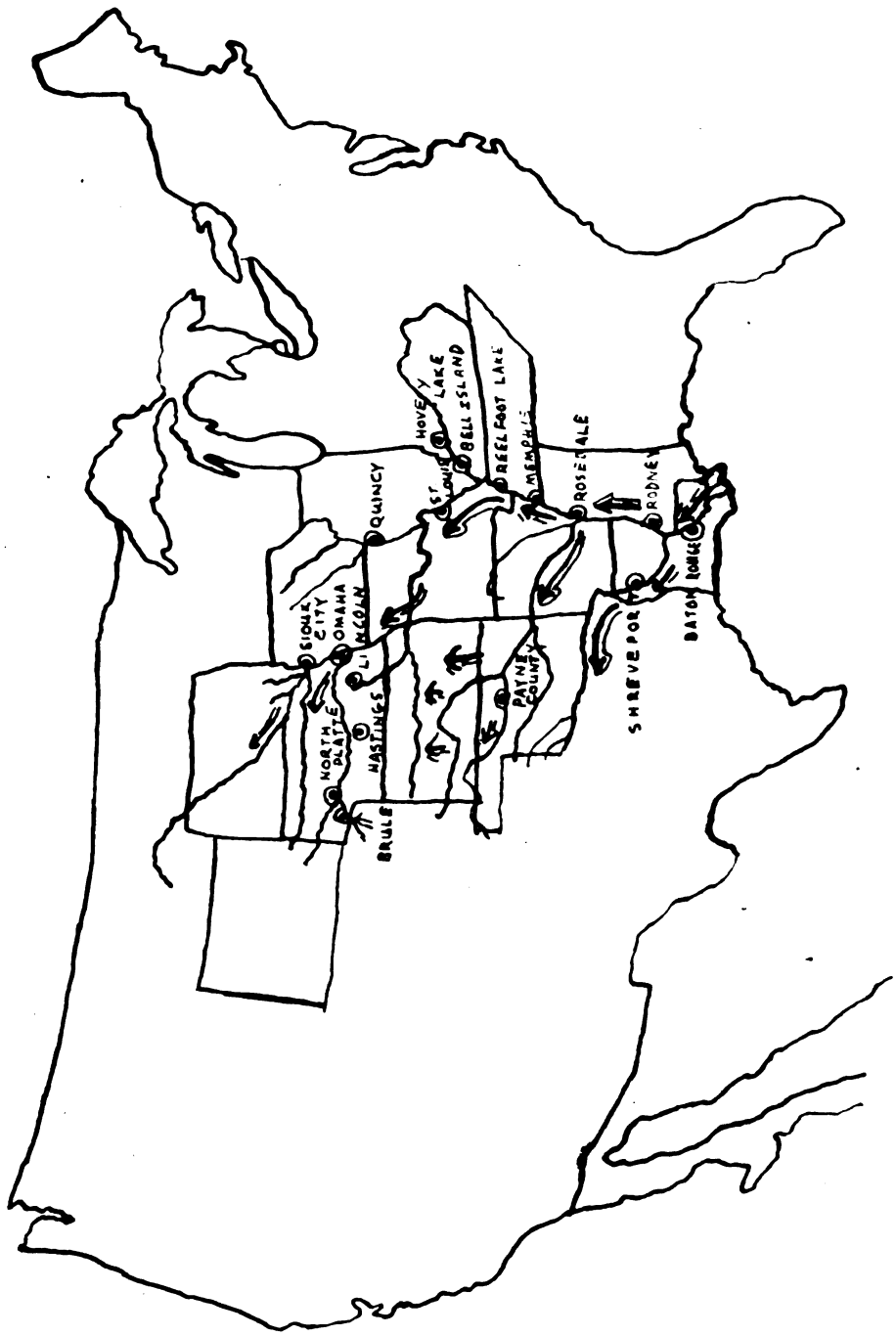

Figure 3. Probable spring migration routes of the interior least tern. Routes are denoted by arrows. Place names are those mentioned in the discussion of spring migration.

Occurrence in Summer

During the summer months the interior least tern is confined chiefly to the vicinity of the larger rivers. Figure 4 gives the locality of the summer records to be mentioned. The number in parenthesis following each record denotes a corresponding number on that map. The following does not purport to present all known areas of summer occurrence or breeding, but the records given provide a basic pattern of distribution during the nesting season.

Louisiana. The interior least tern occurs in this state on the Mississippi River from Baton Rouge northward. Beyer (1907) found terns at Tallulah in Madison Parish (1) in July, but found no evidence of breeding. The species is now known to breed rather commonly all along that stream. Jeter states that the birds are common at Shreveport on the Red River (2) and found them nesting in July, 1950.

Mississippi. The terns are confined to the west side of the state along the Mississippi River. Mabbett (1890) found them nesting at Rodney in Jefferson County (3) and Vaiden states that they breed commonly at Rosedale in Bolivar County (4).

Tennessee. The birds are restricted primarily to the Mississippi River in this state. Bartsch (1922) recorded as a nesting colony what was probably a migrating flock of adults and young on a sandbar in the Tennessee River in late summer. Ganier (1930) recorded terneries on Middle Bar in Obion County (8) and in Shelby County north of Memphis (7), in 1928 and 1929. At Memphis, Coffey states that numbers of terns varies with the condition of the river and sandbars. The birds were not common in 1953 because of a principal nesting bar being washed out. On a float trip down the river from Memphis to New Orleans Coffey observed terns in

only a few places, usually near towns.

Kentucky. Monroe considers the least tern a rare breeding bird in the lower Ohio and Mississippi River areas. Mengel states that it is rather common in some places and that a large colony exists now in Fulton County (9) on the Mississippi River. Meslowski discovered a few pairs there in 1937 and collected two eggs. Formerly, Monroe states that the tern was an uncommon breeder at Paducah in McCracken County.

Illinois. The least tern is rare and local here in summer. Bartsch (1922) recorded as a nesting colony what was probably a migrating flock of adults and young on Bird Point near Cairo (Alexander County) in late summer. Brewer and Hardy (Nolan, 1952) discovered a colony of terns on Bell Island north of Shawneetown in Gallatin County, Illinois, in July, 1952 (10). The group was still present in 1953. This was the first definite breeding record for the Ohio River and for Illinois. Comfort (Nolan, 1952) states that on July 12, 1952, two downy young were observed on Mosenthein Island in Madison County (11) by Anderson. Anderson observed adults feeding young at Horseshoe Lake in St. Clair County, in 1953, but since the young were able to fly this is not a definite breeding record.

Indiana. The least tern is not known to breed in this state. Butler's (1898) record of the species nesting at Wolf Lake in Lake County in Northern Indiana is probably a mistake since his description of the nest fits that of the black tern (Chlidonias niger).

Missouri. The species is a rare summer resident in Missouri. Bennitt (1952) states that Alexander watched adult birds feeding young on the Missouri River in Layfayette County in 1918 (32). King (Nolan, 1953) found terns nesting at Mud Lake in Buchanan County in 1952 (31).

Arkansas. No published records exist for the species in this state. Vaiden writes that both the Arkansas and White Rivers have colonies of terns near their junctions with the Missouri River in Desha County (5,6). It may be assumed that colonies also exist on the Mississippi and Arkansas Rivers.

Oklahoma. The least tern is fairly common and widely distributed in this state, with more records from the central and western portions. Nice (1931) lists the following summer records: * Pittsburg and McIntosh Counties (North Canadian and Canadian Rivers)--1929 (18); McCurtain County, Red River--1925 (19); Old Greer County--1901; Cleveland County, Canadian River (17); Woods County, Edith Salt Plain, (Salt Fork) (22); Harper County (Cimarron and North Canadian Rivers)--1926 (21); Harmon County (Salt Fork and North Fork of the Red River)--1923 and 1926 (15, 16); Cherokee County (Salt Fork); Cimarron County (Cimarron River)--1930 (20). Baumgartner found a small colony on the Cimarron River in Payne County in 1946. Lewis (1930) writes that the species is a summer resident on Horse Creek, a small tributary of the Cimarron River.

Kansas. Long (1940) states that Tiemeier found a small colony on the Arkansas River near Coolidge in Hamilton County (24), and this appears to be the only published record for the state.

Nebraska. The least tern is a common and widely distributed species in this state. Heineman (1943) discovered two nests in July at Merritt's Beach in Cass County (33). Moser (1940, 1943) observed a ternery on the Missouri River in Douglas County (34). Haeker (1937 a,b) found colonies on the Missouri River in Thurston and Burt Counties (35, 37). Stiles

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* Names of rivers in parenthesis were not designated by Nice but are the principle rivers of the counties given.

(1938) observed colonies on the Missouri River in Dakota County (38). The birds occur along the Platte River into Wyoming and nearly to Colorado (South Platte). Haeker and Moser (1945) give the species as nesting west only to York County (30), but this is an apparent error. Wycoff (1950) states that a ternery has been present on the Platte River in Dawson County (29) since 1942. Tout (1947) records the species as a common summer resident in Lincoln County on the Platte River (28). Benckeser (1948) observed a small colony on the South Platte River in Keith County (27). On the Niobrara River, Hudson (1939) observed single terns near Spencer (county?) and Meadville in Brown County in early June. Youngworth has observed the species "well out on the Niobrara River."

Wyoming. There are no breeding records for the state, but McCreary (1934) recorded birds near Torrington and Fort Laramie in Goshen County in early June (26, 25).

Iowa. The least tern is a regular summer resident along the Missouri River north to Sioux City in Woodbury County. Youngworth (1930, 1931, 1932) has recorded colonies at Sioux City regularly (36). Dumont (1933) reports that it breeds in Pottawattmie County on the Missouri River (near 36), and this is further substantiated by Pettingill (1933). Early records indicate that the range of the least tern in Iowa was formerly much more extensive. Dumont (1933) states that it bred in Cerro Gordo County (Clear Lake) (14) and probably Lee County on the Mississippi River (12). He also states that birds have been observed in Sac, Linn, Polk, Sioux, and Winnebago Counties. Praeger (1[illegible]) states that least terns have been seen in summer on sandbars in the Des Moines River near Des Moines in Polk County (13). Johnson (1936) observed the bird as a migrant in Dubuque County on the Mississippi River.

Morrissey states that in over 15 years of intensive observation he has observed no terns at Davenport in Scott County, indicating that the eastern populations are now gone.

South Dakota. The least tern is rare in this state. Over (1921) merely lists it as occurring in summer, but Visher (1915) found it nesting for years on the Vermillion River in Clay County (39). Agersborg (1885) lists the species as a summer resident in Clay, Yankton, and Union Counties.

Early records indicate that the least tern once summered in Montana and North Dakota. Coues (1874) records the taking of specimens by the members of the Warren Expedition on the Loup Fork and Yellowstone Rivers in Montana. Youngworth believes that even today a summer's search would reveal scattered terns all the way to the Yellowstone River.

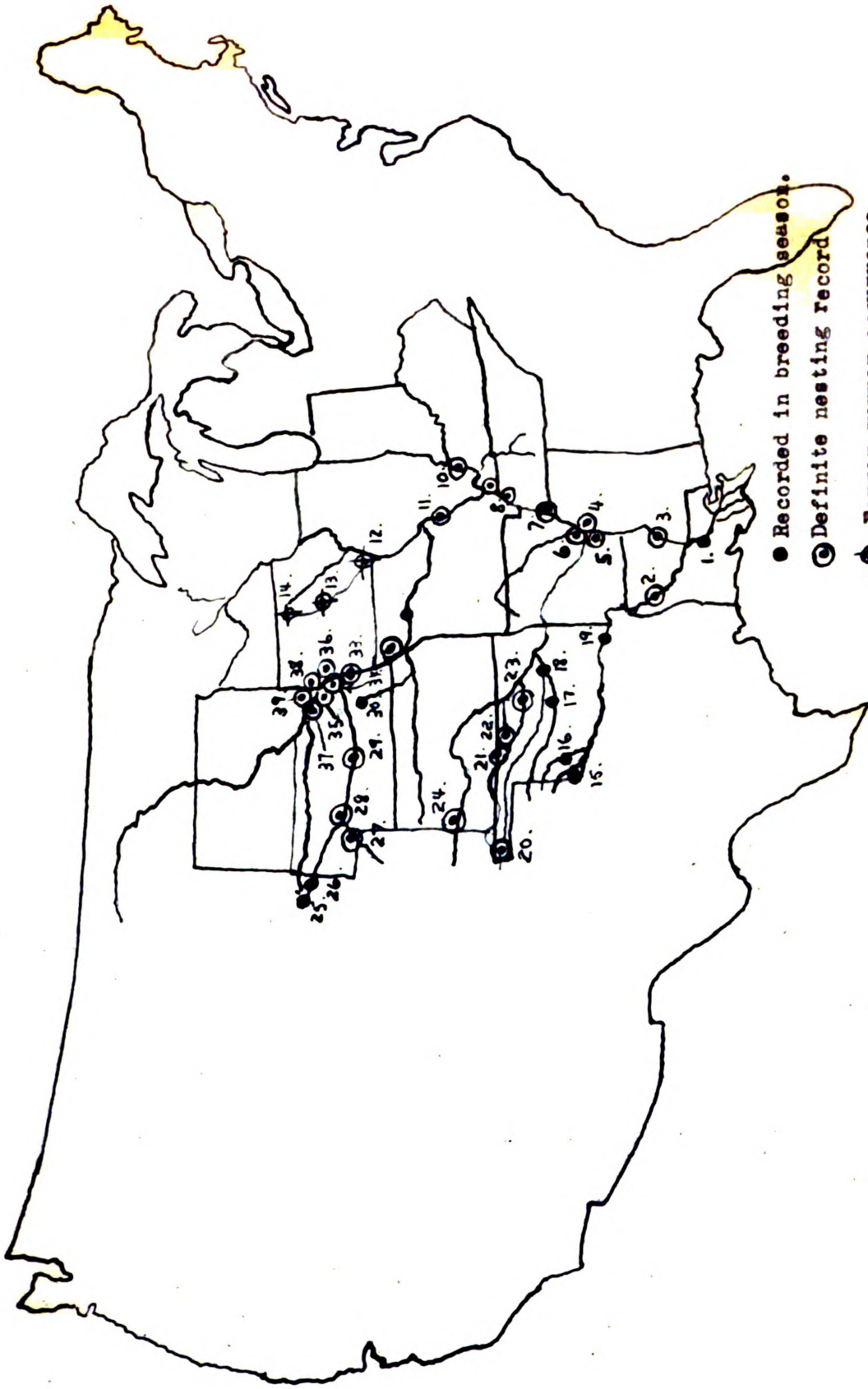


Figure 4. Summer distribution records of the interior least tern. The numbers beside the records denote a specific locality mentioned in the discussion of summer occurrence.

Post-nuptial Wandering

After the breeding season, from early August until mid-September, least terns gather in small flocks and can be found scattered along the streams, and around lakes, ponds, and mud-flats. These movements will be discussed under post-breeding activities but their extent deserves mention here. Extensive wandering is, in particular found among the immature birds. Bent (1947) states that they wander north to Minnesota, Ontario, and Nova Scotia, although many of these records are doubtful. At the falls of the Ohio at Louisville, Kentucky, they are occasionally noted in August and September. Monroe has recorded their appearence there from August 2 to September 21. Mumford observed an individual there on August 14, 1953, and states that Brecher and Lovell saw a least tern at the falls on August 19, 1950. According to Mumford several sight records exist for the Indianapolis region. Butler (1898) mentions a specimen from Brookville, Indiana, taken on August 22, 1887. Maslowski writes that a male and female least tern were collected on the Ohio River in Hamilton County, Ohio, on September 8, 1873.

Rarely, the species is noted even further away from its summer range. Jung (1935) collected an immature female on the Lake Michigan shore at Bar Creek, Sheboygan County, Wisconsin on August 19, 1934. He also mentions an immature female in the Milwaukee, Wisconsin Public Museum collection. Campbell (1934) collected two immature females on Lake Erie in Lucas County, Ohio, on September 16, 1934.

Fall Migration

In fall migration it seems probable that the interior least tern follows much the same routes as in spring but apparently the migration is much more casual and irregular. It is not definitely known whether adults always migrate with the young birds. The writer observed mixed groups of least terns, adults and young, which were probably migrating on August 30, 1953, at Bell Island. The dates of fall movements are often conflicting. Thus, the vagueness of the situation precludes the possibility of analyzing the migration with any accuracy.

At Sioux City, Iowa, Youngworth states that departure is usually before September 1, with only two later dates, viz., September 5 and 8, 1929. He (1931) observed a flock of about 150 birds on a lake near the Missouri River on August 3, 1931, and states that the gathering was in preparation for migration. However, Stiles (1939) working in the same region states that river conditions often do not allow nesting until August, resulting in young still not able to fly by the latter part of that month. Thus, the beginning of fall migration varies with the time of nesting. Perhaps the latest fall record for Iowa was of a bird found dead at Wall Lake in Sac County on September 29, 1912, (Dumont, 1933).

In Nebraska, Tout (1947) states that in Lincoln County his latest record of departure was September 21 (1935). Other records from the state agree in general with this date.

In Illinois probable migrating terns were observed at Bell Island on August 29, 1953, and also at the Carbondale Reservoir in Jackson County on August 30, 1949.

In Oklahoma, Baumgartner noted terns in Payne County on the Cimarron

River until October 7 (1946). Nice (1931) gives an October 21, 1877 date recorded by Coues at Camp Supply.

At Memphis, Coffey has kept migration records of the birds since 1928, and finds that the terns are very irregular in their departure dates in fall. In 1933 one individual was seen on September 24, but from 1928 to 1953 the terns have been observed in only nine years after September 1. In 1953, when the species was rather near Memphis, no birds were seen after August 2.

In Mississippi, Vaiden has observed the least tern as late as October 5 (1921) and October 14 (1930) at Rosedale in Bolivar County.

Beyer (1907) noted flocks of eight or ten birds in Louisiana in fall, but gave no dates.

Winter Occurrence

Not much is known of the distribution of the race athalassos in winter. Bent (1947) gives the winter range of the North American races as follows:

> "From the Gulf of Mexico (Louisiana coast) south along the east coasts of Central and South America, to Argentina (Corrientes); and from the Gulf of California, south, along the west coast to Peru (Serayacu)."

Beyer (1907) observed least terns in small flocks far inland in Louisiana in winter but it cannot be certain that these were interior birds, since no separation of the race was made at that time.

FACTORS GOVERNING OCCURRENCE AND BREEDING

The interior least tern does not occur everywhere along the streams previously mentioned. Its localized pattern of distribution is the result of an interplay of several related ecological factors. Basically, these are: (1) the presence of sandbars, (2) the existence of favorable water level conditions during the nesting season, and (3) the availability of food.

Sandbars

Type I. The formation of sandbars in rivers is the result of erosion and deposition by the current. These sand and gravel accumulations are characteristic of two geological stream types. The first type is found in the eastern portions of the terns' range, where sand deposition is caused by rivers reaching grade level. To illustrate, the Mississippi River in its course from the northern United States to the Gulf of Mexico reaches grade (becomes "mature") near the southern tip of Illinois. From this point on it is nearly level with the Gulf. This results in a retardation in the rate of flow, the velocity being supplied principally by the force of the head waters. It can theoretically dig no deeper, being inhibited by the water level of its "master," the Gulf of Mexico. It assumes certain characteristics which are favorable for least tern nesting. Its course becomes meandering over a broad flood plain, and the slowing of the current causes the deposition of suspended sediments and the resultant formation of sandbars and shallow water areas. The Ohio and Missouri Rivers' master is the Mississippi River. In their headwaters these two streams are relatively straight, with narrow valleys, strong currents, and fewer sandbars. As they approach the Mississippi River they mature and begin to drop sediments which form

bars. Sandbars also occur on immature streams where a temporary grade is reached or a tributary stream causes slowing of the current. The Missouri River exhibits these last characteristics on its upper waters.

The least tern in not known as a breeding species on most parts of the Ohio River. Above Owensboro in Daviess County, Kentucky, the stream is relatively immature. Below this, sandbars are common. (See Figure 8 for illustration of the immature stream conditions.)

The Mississippi River north of its junction with the Missouri River is an immature stream. Formerly the many tributaries on its upper waters provided enough sandbars, at least in the eastern Iowa region so that least terns occurred sparingly in summer. Morrissey states that in recent years the maintenance by river authorities of a nine-foot channel by dams along the river has prevented the formation of sandbars. On a flight from Davenport, Iowa, to St. Louis, Missouri, he saw no bars above Keokuk, Iowa, where they were once prevalent from June to September.

The building of dams on other portions of the Mississippi and Missouri River system, if continued, may in time further reduce good least tern nesting sites. At Sioux City, Iowa, Youngworth (1932) writes that government work on the channel of the Missouri River, such as revetments, dikes, and pilings, may cause the terns to move further upstream where bars still exist. Figures 5 - 8 illustrate some of the stream characters discussed.

Type II. In the western portions of the least terns' range grade level is a less important factor. On such streams as the upper Missouri, Platte, and Cimarron Rivers the controlling factor in the formation of sandbars is an arid summer condition. In the plains area heavy rainfall comes in winter and spring. At these seasons the streams are at flood

stage and carry large amounts of sediment. In summer very little rain falls. The result is an abrupt lowering of the water level (or complete termination of flow) and consequent deposition of the large quantities of sediments. Figure 7 illustrates these summer conditions. At this time there is often more sand than water.

Duration. The mere presence of sandbars is not the only limiting factor. The life of most bars is short, lasting often only from one flood to the next. Usually, a new bar will be formed nearby so that terns are not eliminated entirely. As mentioned previously, Coffey found the terns rather uncommon at Memphis during 1953, probably because one of the main nesting bars was washed out.

The Bell Island sandbar has existed with frequent changes in form for over ten years. Natives of the area recall its formation at least that long ago. The topographical map of that locality printed in 1938 shows that it was present in reduced size at that time. Probably the larger and older bars gradually acquire the larger terneries, although data are not at hand to prove this.

Height above water. A bar which is immersed by small rises in water level is not suitable for a ternery. The Bell Island bar at its center is about ten feet above the water, and the ternery is situated from about five to ten feet above water. In the plains area where little or no water is in the stream bed during the summer this elevation is less important.

Isolation. Isolation plays an uncertain role in the success of a ternery. A bar which is readily available to land predators and humans is less suitable than a bar completely surrounded by water. Youngworth states that at Sioux City, Iowa, terneries are always located on bars

surrounded by water. Published literature and personal communication indicate that the situation is rather variable.

Bell Island is connected to the mainland, but its large size, a heavily wooded area near this connection, and location of the ternery over one-half mile out on the bar, provide good protection from humans and most animals except other birds.

Water Level Fluctuations

Tern colonies are in constant danger of being inundated by flood waters. Marine least terns occasionally suffer from tides. Hagar (1937) in Massachusetts found least terns nesting so near the ordinary high water mark that any unusual storm or tide washed away the eggs and young. However, the phenomenon of high-water conditions on rivers is far more regular, occurring in spring from March to mid-June.

Ganier (1930) presents data which indicate that the initiation of the breeding cycle of the terns nesting on bars at Memphis, Tennessee, was closely correlated with the fall of the river to normal water level after the "June rise." In even an average spring rainfall the Mississippi River system drains so vast an area that enough high water occurs so that the sandbars are immersed. When the river has reached low water again (by late May or early June) a final rise usually occurs. Ganier (1930) noted that in a period of ten years at Memphis the water dropped lower than bar level about June 18 on the average. Figure 9 shows Ganier's correlations of water levels with beginning of nesting. In 1928, with high water occurring until mid-July, terns nested later. In 1921, with no high water after May, terns began nesting early in June.

Vaiden believes that the beginning of nesting is governed by water levels. He usually observes birds beginning to nest at Rosedale,

Mississippi, between June 10 and 13, since bars generally become exposed during the first two weeks in that month. In some years nesting there has been delayed to as late as July when rains on the upper waters kept river levels high.

Tout (1947) states that in 1928 sandbars on the Platte River in Lexington County, Nebraska, did not appear until July. A visit to terneries on July 28 showed that most of the 18 nests found contained eggs and a few young. Thus, nesting probably began immediately after the appearence of the bars.

In Iowa, Stiles (1939) observed that the Missouri River at Sioux City is usually not low enough for bars to be exposed until the first week of August. This condition in 1937 resulted, as already mentioned, in young still not able to fly in late August. According to Stiles, flood stage at Sioux City is 19 feet. Sandbars start to appear at eight feet. The maximum level for 1937 occurred on June 21 when the water stood at 11.8 feet. The minimum was on September 23 at 1.6 feet. The maximum for 1938 was 13.2 feet on March 24. On June 28, 1938, the water stood at 11.5 feet, but the maximum summer rise was not until July 8 when the level rose to 12.7 feet. Bars became exposed on July 25, 1937, when the river levels dropped to 8.4 feet, and on August 7, 1938, when the gauge showed 7.2 feet.

Apparently the conditions found by Stiles were not typical. Youngworth (1930) has observed young able to fly and being fed by adults at a nearby lake in the Sioux City region on August 7. He also saw a large flock of perhaps 150 birds, including young and old, on a Missouri River sandbar on August 3, 1931 (1931).

At Bell Island in 1953 water levels were such that the bar did not

appear until the second week in June. Figure 10 shows that the June rise began about May 21 or slightly before. The gauge at Shawneetown is out of the water below 20 feet. Pool stage (which may be considered the normal summer condition) is 10.9 feet. Since the bar is approximately ten feet, at its highest point, above pool stage, a river stage of 20 feet would place the water about even with the top of the bar. Thus, before May 13, 1953, the sand was at least partly exposed. It was immersed from May 13 until June 4, at which time it again became exposed. Water levels dropped steadily, according to the official river observer, at Shawneetown, Illinois, until pool stage was reached in mid-June. Nesting probably was initiated soon after the bar appeared, since several nests with eggs were present on June 20. Because of severe drought conditions, water levels remained near pool stage during the remainder of the nesting season and through the autumn. Minor fluctuations of one to two feet occurred periodically as a result of dam operations on the upper Ohio River.

Once low water stages have been reached, large floods are rare in the eastern part of the terns' range. Thus, the great hazard is not destruction of the terneries, but delay in the breeding so that nesting is either exceedingly late or not attempted at all. Vaiden observes that on the lower Mississippi River fluctuations of any great magnitude from rain on the upper waters after the spring floods are rare, since a considerable amount of rain must fall to cause a rise of more than a few inches on the lower river.

The possibility of a sudden rise of water sufficient to inundate the terneries is much more real on the arid plain's streams. Baumgartner states that in Oklahoma nesting sites in the river bottoms and on the

salt flats are at times destroyed by water. The small colony on the Cimarron River in Payne County, according to that writer, must be covered by flash floods several times during some seasons. These streams are nearly dry most of the summer, but their proximity to western uplands subjects them to these flash floods from rainfall in the mountains.

The preceding data would seem to indicate that beginning of nesting is directly correlated with cessation of spring floods. From this it might be assumed that in those exceedingly rare years when almost no rises in water level occur, terns might begin nesting earlier. Ganier's (1930) 1921 correlations (see Figure 9) indicate such a supposition is valid. However, on July 23, 1952, King (1953) found an estimated 15 to 20 pairs of least terns nesting at Mud Lake in Buchanan County, Missouri. Four nests still contained eggs. Mud Lake is an ox-bow lake in the Missouri River bottomlands not far from the river. Thus, it is possible that flood waters did cover the lake in spring. If not this record might be good evidence against the correlation theory.

Further investigation is needed on the problem just discussed. Greater knowledge of beginning of nesting and flood stages might reveal that a physiological adaption has evolved in response to the flood conditions which exist so regularly each year, and that the birds could not nest earlier if conditions were favorable. Youngworth agrees with this theory.

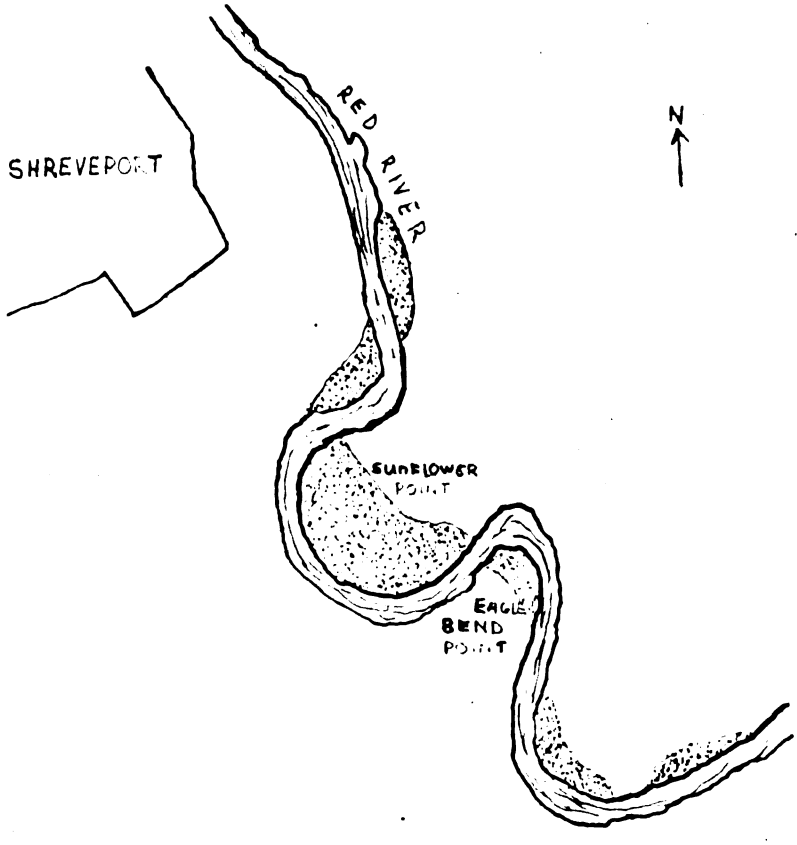


Figure 5. A typical stream at grade level. The Red River at Shreveport, Louisiana. Note the meandering flow and the large bars.

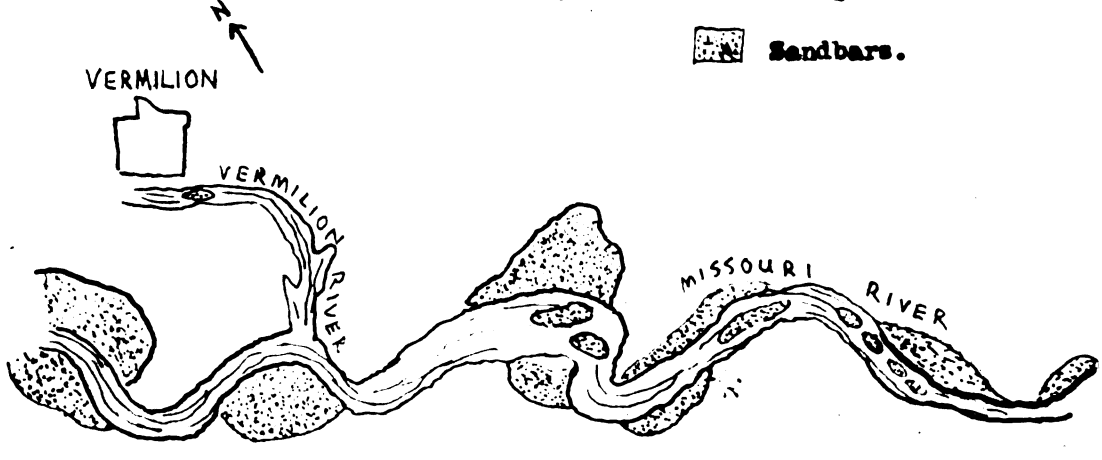


Figure 6. A stream at <u>temporary</u> grade level. The Missouri River near Vermillion, South Dakota. The stream slows down as it flows across level plains. This and the junction of the Vermilion River cause sandbar formation.

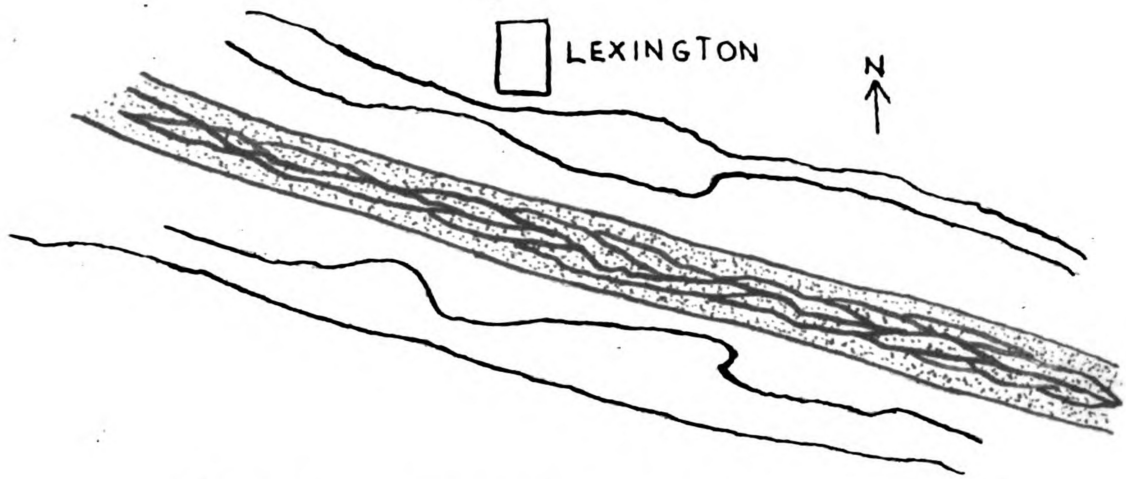


Figure 7. A typical arid plains stream.
The Platte River at Lexington, Nebraska.
The dark lines in the stipled area indicate
the interlacing and extremely small water flow.

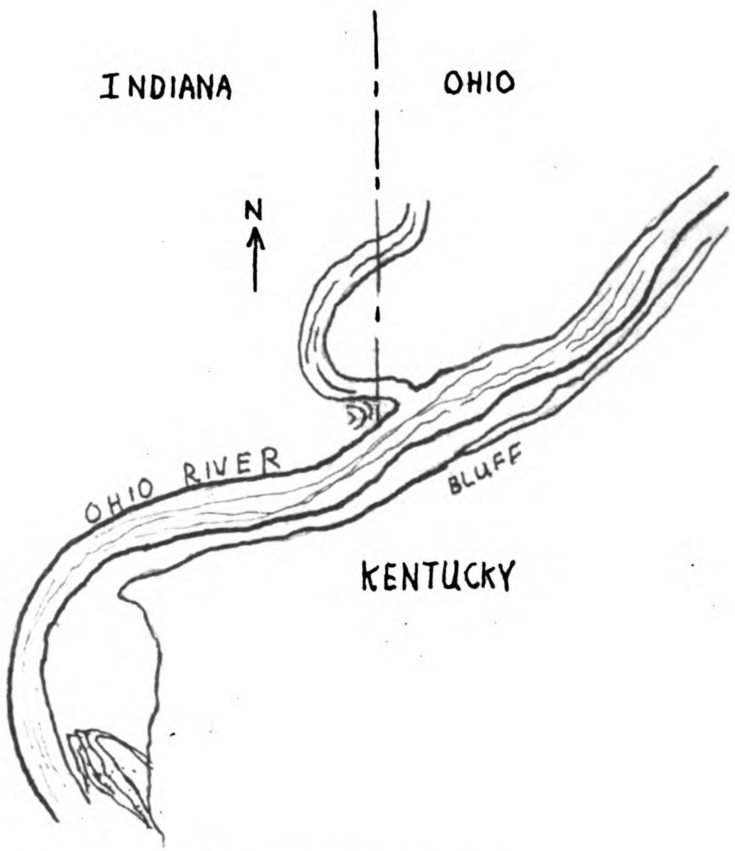


Figure 8. An immature stream.
The Ohio River at the Ohio-Indiana Border
Note the straight course and lack of
sandbars.

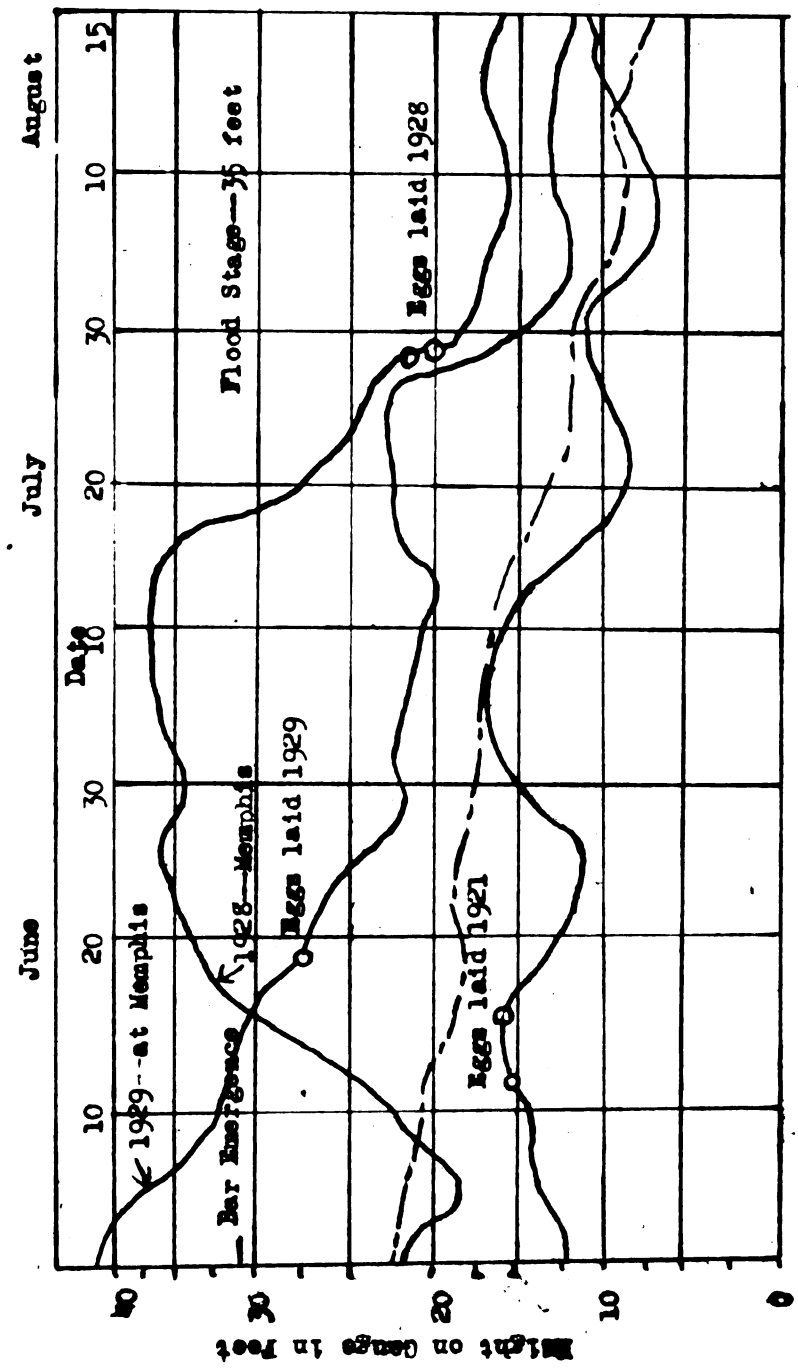


Figure 9. Relation between height of Mississippi River at Memphis, Tennessee, and nesting time of the interior least tern (adapted from Ganier, 1930).

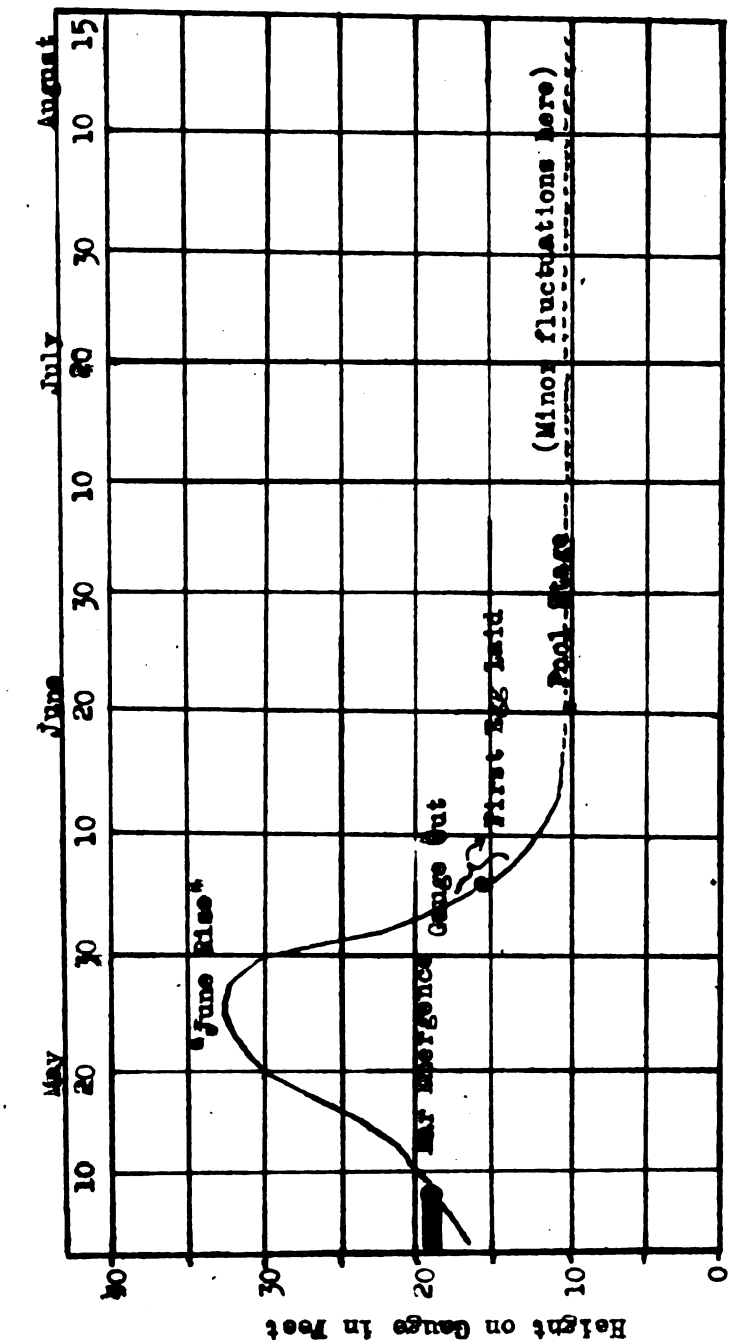


Figure 10. Correlation of water levels with nesting of the interior Least tern at Bell Island in the Ohio River in summer of 1953.

(U.S. Department of Commerce, Weather Bureau, Climatological and Hydrological Observations.)

Weather Conditions

Casual weather observations made by the author in the Bell Island ternery and data provided by the Weather Bureau at Evansville, Indiana, were quite comparable. Rainfall at the two localities differed somewhat; consequently, these measurements were obtained from the official rainfall and river observer at Shawneetown, Illinois, one mile from the ternery. Figures 11 and 12 illustrate these weather conditions.

Temperature. The weather factor of most importance in the life of the ternery is temperature. The nesting site is always completely exposed to the sun, which causes surface temperatures of the sand to range from 5° to 15° higher than surrounding normal air temperatures. Stiles (1939) found that in the terneries near Sioux City, Iowa, sand surface temperatures frequently exceeded 100° F., and he theorized that incubation of the eggs was partially by the sun. He examined one egg which was nearly ready to hatch, but for which his observations indicated little incubation by the parent birds. It is generally accepted that the optimum temperature for successful incubation of most birds' eggs is about 93°. At Bell Island both air and sand surface temperature exceeded this by as much as 15° on many days during the nesting season. Such temperatures would probably be harmful to the eggs. Shielding the eggs from the sun was necessary here to protect them.

High temperatures can also be harmful to young terns. Since no shelter from the sun exists, the young suffer at temperatures of 90° unless brooded by the adults. The author saw no young whose death was attributable to the heat; however, when the chicks were being weighed and marked they usually ran into the shadow of the worker or occasionally inside his trouser leg.

Wind. Wind serves to modify temperature and humidity, but with increase in velocity may cause miniature sandstorms which cover the eggs and/or young. Ganier (1930) believes that such storms may be an important mortality factor. Stiles (1939) found a single egg partially covered with sand, as already mentioned. Examination showed that the fetus was alive. Thus, burying of eggs may not be fatal in itself, but becomes so with the resulting neglect by parent birds.

Tout (1947) found several dead least terns on sandbars of the Platte River at Lexington, Nebraska, on June 17, 1953. A small tornado and a hail storm had crossed the river through the ternery on May 22 and June 7, respectively, reducing the colony to about half its former size.

At the Bell Island ternery no sandstorms were observed that were large enough to cause any damage to nests or eggs. Composition of the substrate is an important factor in the effectiveness of the wind. The Bell Island bar is largely coarse sand, but the majority of the terns' nests were on the gravel accumulations which are not affected by ordinary winds.

Rain. Summer in most of the Mississippi River drainage is a period of low rainfall. When local rains occur they are usually thunderstorms, bringing torrential downpours. Their effect on the terns is occasionally disastrous. On July 8, 1950, Jeter found a ternery at Shreveport, Louisiana, that had suffered considerable damage by rainfall. He found a broken egg-shell, an egg in the sand which had been washed from the nest, and nests which appeared to have been disrupted.

The year 1953 was one of severe drought in the Midwest, and consequently rainfall at Bell Island was negligible with no damage inflicted. Associated with this was the percentage of sunlight. Table I shows that

few overcast days were recorded at the ternery, and also summarizes the other weather conditions.

Food

Composition. The food of the least tern consists almost wholly of aquatic macroorganisms. The Marples (1941) found that the principle diet of the species in England consisted of 1.87 per cent fish, 96.88 per cent crustacea and 1.25 per cent marine mollusks. They found no trace of freshwater forms in the diet. Collinge (1929) states that the least terns at Blakeney Point, Norfolk, England, fed principally on fish, sand eels, annelids, mollusks, and crustaceans. Witherby (1941) writes that the least tern's diet, based on analysis of six stomachs, consisted entirely of animal matter of which 97 per cent were crustacea (Mipidacea, etc.) and Annelida, 2 per cent were fish, and 1 per cent were marine Mollusca. Four stomachs reported by other writers contained small fish and one was full of sand eels (Ammodytes).

Such a variety of food is not available to the interior least tern. Observations indicate that its diet consists almost wholly of fish; however at Bell Island, Brewer examined the stomach of one specimen and found that the contents were one small unidentified seed, and a fragment of an unidentified insect. It is probable that these were both contained in the diet of a fish which the bird had eaten. At no time during the observations were the terns seen to catch or carry anything except small minnows. These were occasionally found on the sand where they had been dropped by the birds. They all appeared to be of the same species, but were hardly identifiable in their always mutilated condition.

On July 27 the author seined the shallow waters immediately sur-

rounding the island where the birds fed. Using a 20-foot seine, four 30-foot circular drags were made. The collected fishes included 297 minnows (Notropis blennius); 37 suckers (Ictiobus sp.); 1 gizzard shad (Dorosoma cepedianum); and 1 sunfish (Lepomis sp.). All were less than two inches in length. The river shiner (Notropis blennius) proved to be the same as those found discarded by the birds, and probably was the dominant food of the terns.

Availability. Terns are seldom seen feeding outside the shallow water areas of the river. Many writers have noted that they feed on nearby shallow lakes and bayous, where these occur near the terneries. On those parts of the river where sandbars are abundant there are nearly always many shallows. Where these do not occur the birds may have to go long distances for food. In the arid plains regions the streams often go completely dry and the birds then seek water holes and congregate in large numbers to feed. Tout (1934) found such a situation in July, 1934, when there was no water in the North Platte or South Platte Rivers west of the Lincoln County, Nebraska line. Water was present in waterholes from Birdwood Creek and drainage ditches, and here dozens of least terns were gathered.

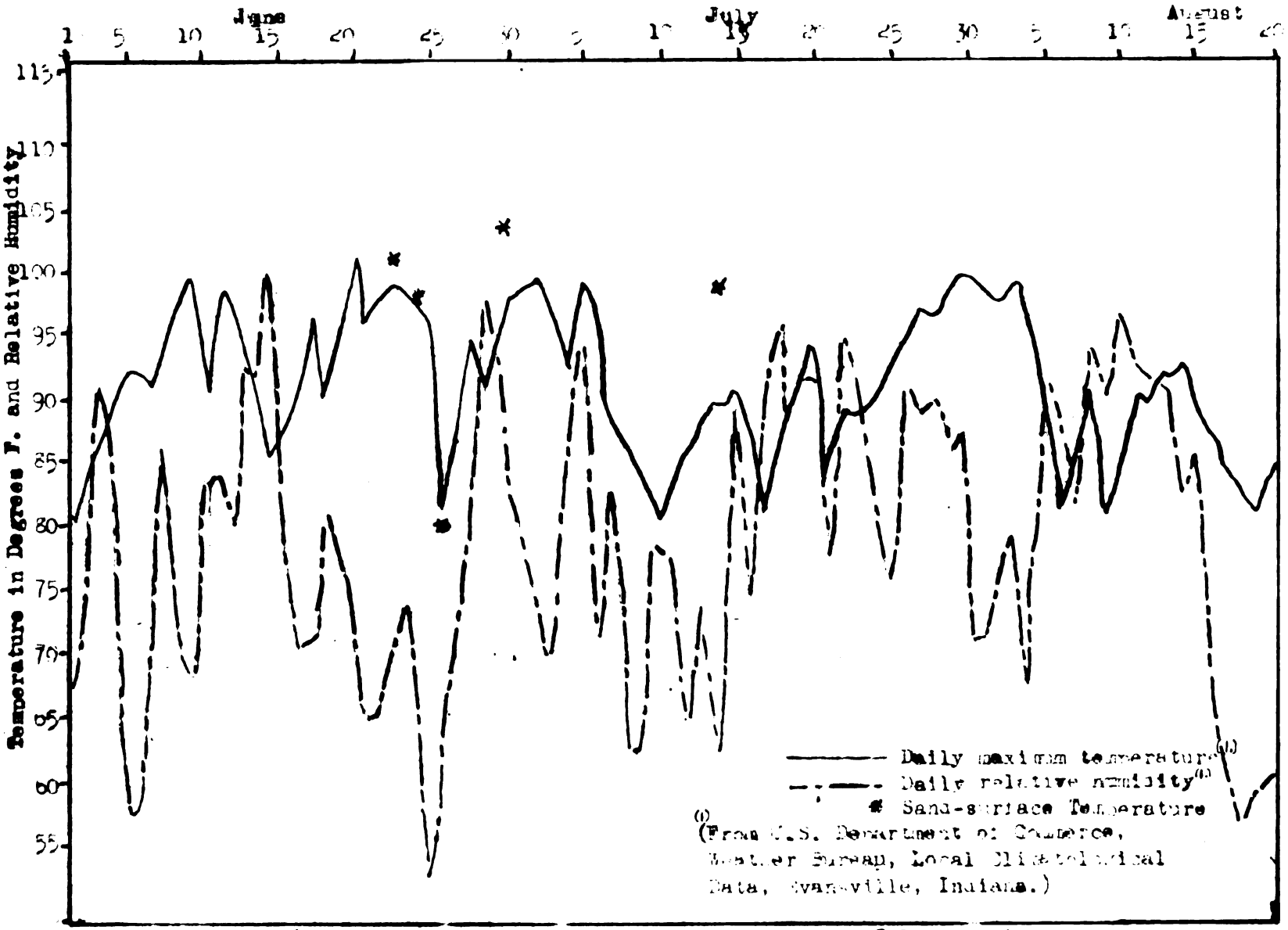


Figure 11. The temperature-humidity relationship in the Ball Island region.

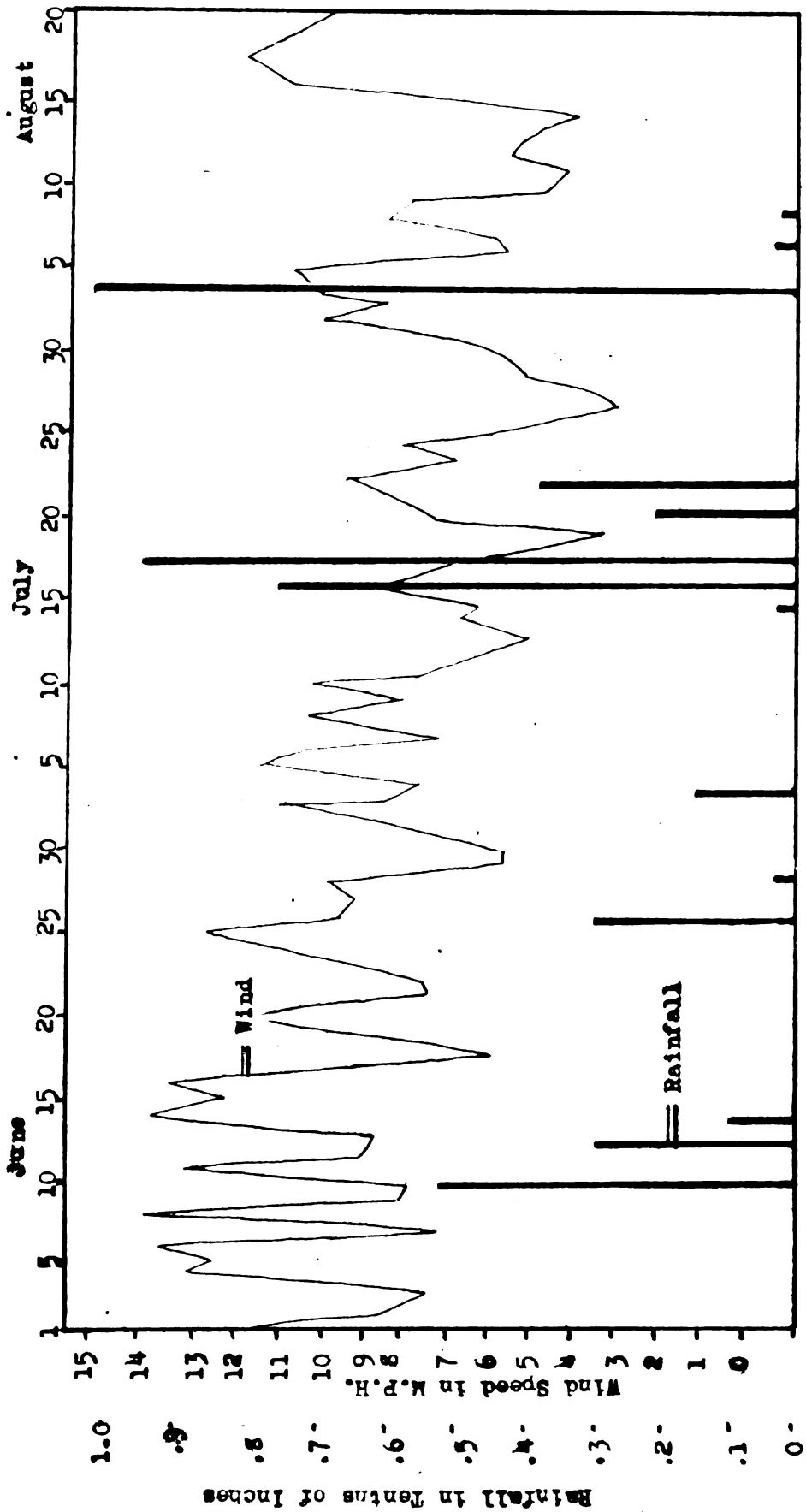


Figure 12. Rainfall and wind conditions in the Bell Island region.

(From U.S. Department of Commerce, Weather Bureau, Local Climatological Data, Evansville, Indiana.)

TABLE I. SUMMARY OF PRINCIPAL WEATHER FACTORS FOR THE LOWER OHIO RIVER VALLEY IN SUMMER 1953.

1953	Temperature (Degrees F.)			Precipitation (Inches)	Wind (M.P.H.)		Sunshine (Per Cent)
Month	Max.	Min.	Ave.	Water	Ave.	Max.	
June	101	53	80.2	1.49	9.4	47	90
July	98	54	79.9	2.43	7.1	31	87
August	100	53	77.1	1.21	6.7	29	90

Additional Remarks.

June was the fourth warmest and driest June on record with an average temperature 5.6° above normal. On 23 days the temperature exceeded 90°. The average relative humidity was 75 per cent.

July had 20 days with temperatures over 90°. The average relative humidity was 81 per cent.

August had 18 days with temperatures over 90°. The average relative humidity was 78 per cent.

All data except precipitation records from U.S. Department of Commerce, Weather Bureau, Local Climatological Data Summary, Evansville, Indiana.

Precipitation data from Climatological and Hydrologic Observations supplied by the official observer at Shawneetown, Illinois.

LOCATION AND DESCRIPTION OF THE SUMMER STUDY AREA

Location

Bell Island is an island only at high-water stages. At normal summer water level it is a peninsula extending downstream from the Illinois shore of the Ohio River, located at latitude 88°5'; longitude 37°43'. On the United States Geological Survey topographical map of the Shawneetown, Illinois quadrangle it is situated in township 9 south, range 10 east. Figure 15 is adapted from the topographical map and shows the overall view of the island and river.

There is some question as to whether the sandbar is located in Kentucky or Illinois. Local authorities consider it a part of Kentucky. According to United States Geological Survey Bulletin 817 (1930) the north bank of the Ohio is the north boundary of Kentucky, the exact line being fixed by the low-water stage of the river. Since at low-water the island and bar are broadly connected to the mainland of Illinois, it will be considered as part of that state in this paper.

Description

Bell Island is one of the largest and oldest islands on the lower Ohio River. From its junction with the mainland to the outermost tip it measures approximately 6633 yards. The higher, older and more stable portions are covered with a dense flood-plain forest similar to that on the adjoining river banks. The trees range from about two to five inches in diameter. The dominant species are black willow (Salix nigra), cottonwood (Populus deltoides) and red maple (Acer rubrum).

The sandbar extends 2493 yards downstream from the outermost woodland, and at its widest point it is about 600 yards across. The total area is 860,805 square yards or about 120 acres. Its height above water level

away from the shore ranges from five to ten feet, and this portion of the bar forms a sort of plateau sloping gradually to the water on the mainstream side, dropping off sharply to the water on the lagoon side (between the peninsula and the river bank), and falling rather abruptly near the point to an area of silt and sand so near the water level that it is submerged with the slightest rise. Figures 13 and 14 give some idea of the large size of the bar, and illustrate some of the points just mentioned.

Figure 13. The mainstream side of the bar. Note the gradual slope of the shoreline to the water.

Figure 14. Looking upstream over the broad expanse of the bar. Note the driftwood accumulation left by receding floodwaters.

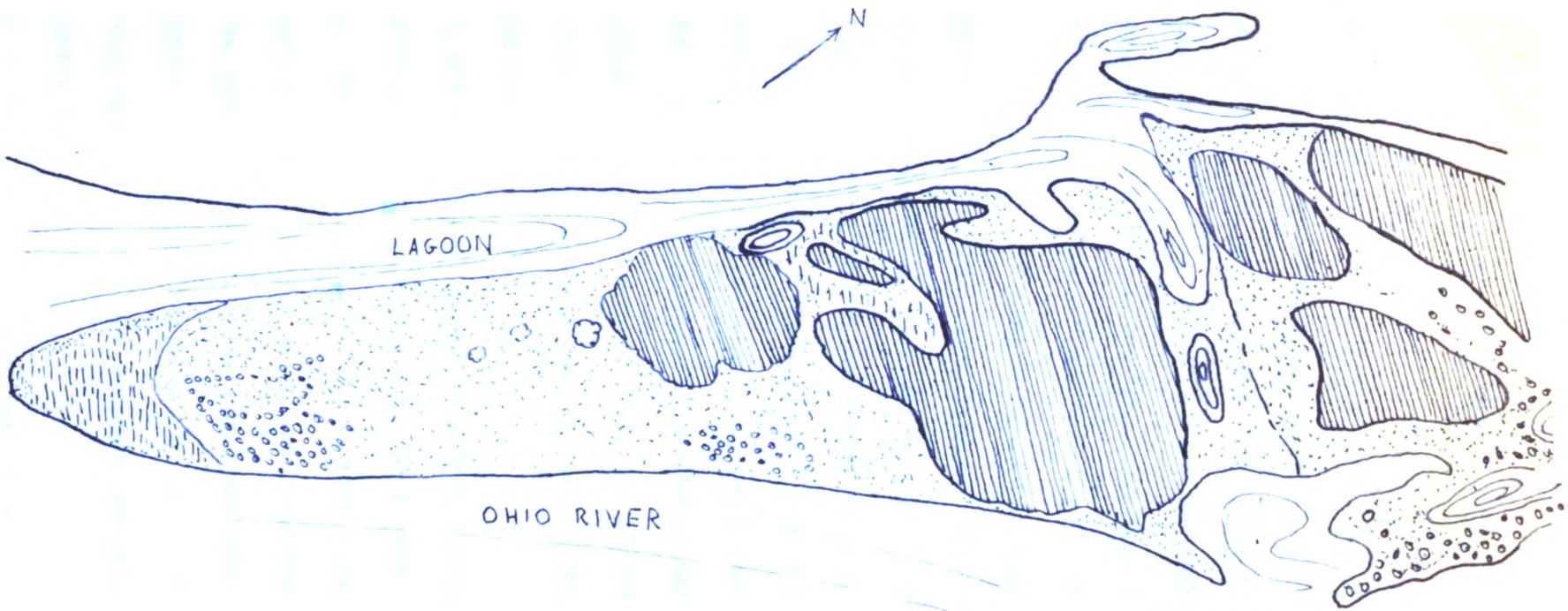


Figure 15. Bell Island

THE BREEDING CYCLE

At the time of the writer's arrival on June 19, egg-laying was well underway and most of the courtship had been completed. In an attempt to piece together the basic elements of the pre-parental phases of the cycle, it was necessary to rely to a great extent on the observations of others. Richard Brewer made limited observations in the vicinity of the ternery several times during April and May, and a few observations of courtship were recorded after the author's arrival.

Arrival in the Nesting Area

Several authors, including Palmer (1941) and the Marples (1934), have described various methods in which common terns arrive in the general area of a ternery. The author found no such classifiable arrival habits with the interior least tern, either from the literature or from personal observations. The birds travel in small loose flocks, and their arrival in the region of the ternery is gradual. Vaiden, though he emphasizes that his observations were casual, has observed flocks of from 5 to 20 birds probably in migration and feeding along the river near Rosedale, Mississippi.

It has already been shown that from mid-May until early June in the central part of the birds' range flood waters usually cover the nesting bars. Thus, when the terns arrive they cannot go directly to the ternery but must wait for the water to subside. At these times they can be seen feeding along the river and nearby bodies of water or perched on drift accumulations. Courtship may begin at this time. However, until the bars are exposed, continuation of the cycle beyond courtship is halted.

It is this fact which sets the interior least tern apart from coastal

nesting terns, since the latter are almost never deterred in the breeding cycle by flood waters and may begin nesting activities as soon as they arrive. Thus, Palmer (1941) and the Marples (1934) found in their studies of the common tern that in mid-nesting season nearly all phases of the breeding cycle were being carried out concurrently by different pairs within the ternery. Individuals which had arrived late were in courtship, while other pairs nearby incubated eggs.

With the interior least tern the activities of almost all members of a colony are synchronized by the high waters so that with few exceptions all pairs are in the same phase of the cycle at the same time.

Courtship

Courtship display in terns is rather well known. The same basic performance is found in nearly all species with variation in each species and in individuals. In the least tern the different phases of display in their approximate order are as follows: aerial glide, posturing, parade, copulation, and incipient nest-building.

The author observed courtship among a group of about 10 terns at Bell Island on June 20. These were birds which had arrived late, since egg-laying was underway in the ternery. They were perched on the mud-flat point of the bar or flying over it (see Figure 15). It should be stated that designation of individuals as male or female in this paper is not certain, but is based on the actions of the birds, occasionally corroborated by observed copulation.

Aerial flight. On several occasions a tern carrying a small fish flew and glided at a height of about 50 feet with another bird following closely. Their positions soon reversed. In flight they maintained a peculiar quick deep wing stroke. Palmer (1941) states that the aerial

glide in common terns is a continuation of the fish flight, a social activity taking place before courtship. There is apparently no well-defined fish flight in the least tern. In fact, in contrast to the well-defined and complex flights of the common tern, the aerial glide in the least tern is rare and seemingly insignificant.

Posturing and parading. Whereas the aerial glide may at times be a social activity, posturing is an integral part of courtship. According to Palmer (1941) the activities of courtship are not necessarily a part of the mating phase, since it is extremely probable that actual pairing of the terns has already taken place earlier in the spring, or the birds have been mated since the previous summer. Courtship, thus serves to break the social relationship behavior, inhibit male behavior in the female, synchronize the reproductive states of the pair, maintain the sexual bond, and assert dominance.

In the interior least tern the aerial glide may be quickly followed by the birds coming to earth and posturing. The following is an account of a typical example of posturing and parading observed at the point on June 20.

As several birds stood near the edge of the water another tern, probably a male, flew over the group with a little fish. All the birds in the group called kueu-kueu-kueu-kueu as the flying bird "A" passed overhead. "A" alighted beside one individual "B" in the group and offered the fish. Instead of taking it "B" rushed at "A" and attempted to peck him. "A" then flew hurriedly away but soon approached another tern "C", still carrying the fish, and presented it to "C." Instead of rushing at "A", "C" assumed an erect pose--with head held high. "A" then assumed a bent posture--with back hunched, head down, wings drooped,

and bill parallel with the ground. Holding the fish near the caudal fin, "A" stood still while "C" shuffled in a counterclockwise direction around him. "C", after making about one circle, suddenly took the fish from "A" and ate it. "A" then postured with bill pointed upward at 45° and wings raised but directed backwards. In other observations of the same procedure the "C" bird did not eat the fish but dropped it after holding it momentarily.

In the first presentation to "B" the negative reaction of that bird indicated that it was also a male bird. Terns apparently cannot distinguish between sexes by plumage but rely on the described procedure.

The point area probably was not part of the ternery, since the birds disregarded the observer here in contrast to their defense reactions in the nest area. Thus, courtship, in contrast to that in common terns (Palmer, 1941), did not take place within the ternery, at least while the writer was present.

Copulation. Courtship behavior at Bell Island was not observed to terminate in copulation. Stiles (1939) found that least terns at Sioux City, Iowa, began copulation soon after arrival in May and continued through June and July. At Bell Island copulation was not observed after the third week in June. The following procedure of the sexual act was noted at the point (where the courtship observations were made). It was not preceded, at least immediately, by the parade.

Two birds stood side by side. One was in an erect position, the other stooped with head down and wings slightly extended at the sides. Both birds moved their heads from side to side. The erect bird moved close to the crouched bird and mounted. Both birds called kueu-kueu-kueu-kueu with bills closed. Copulation lasted about three seconds during which

time the birds' bills were interlocked. Subsequently the male flew away and the female remained. She preened passively and gave no call.

Stiles (1939) observed an interesting variation in the courtship procedure. The routine which he describes seems to combine the aerial glide and copulation and omits the posturing and parade phases. After execution of the aerial glide (as described earlier) the female plummeted to the water followed by the male. This may have been the fish chase of Palmer (1941) or the vee soar of the Marples (1934). The birds were very close together in this dive, and as they alighted on the water the female took the fish from the male which was almost on her before they reached the water. Copulation took place quickly and lasted only a few seconds.

Incipient nest-building. This includes scrape-making and pebble-tossing in the least tern. It may occur before or after copulation. Both sexes participate, but according to other workers these actions by the male stimulate the female to perform similarly. Terns at Bell Island were not observed to make these artificial nests during courtship, but the bar was covered with hundreds of depressions, made by the birds, which contained no eggs. It may thus be assumed that the act was performed earlier. Pebble-tossing replaces the twig-tossing observed by Palmer (1941) in common terns. Since least terns use no materials other than the gravel substrate in constructing nests the reason for the substitution is obvious. Pebble-tossing was not noted in the courtship at Bell Island, but, as Palmer (1941) points out, such activity may be carried over into other phases of the cycle as a substitute activity employed in times of anxiety. Thus, at Bell Island, the pebble-tossing was noted in birds which were anxiously attending the young in the face of some danger such as the presence of other birds or humans.

The Ternery

As soon as the nesting bar becomes exposed it is occupied by the terns. The sand dries quickly, so that the birds are not hampered by moist conditions. At Bell Island, egg-laying probably began very shortly after occupation, for at the time of the writer's arrival on June 20 the bar could not have been exposed more than ten or twelve days; still most of the nests contained eggs.

Size of terneries. The size of interior least tern colonies is variable and is difficult to correlate with any physical characteristics of the habitat or with the area of occurrence within the range. In general a direct relation exists between the size of the bar and the colony. The larger colonies usually occur on the larger rivers which possess the larger bars, although there are exceptions to this.

Vaiden believes that 20 pairs is about the maximum number per colony in the Rosedale, Mississippi, region on the Mississippi River. This is fewer than found by other workers on the lower part of that river.

Coffey (Ganier, 1930) found about 50 birds present on Middle Bar near Memphis, Tennessee, on July 31, 1928, and found three nests in this colony on August 3. It is probable that this small number of nests is not good evidence of the size of that ternery. Austin (1949) states that there are few non-breeding adults or "drones" in common tern colonies, therefore the number of birds can be used as a good indication of the size of the nesting population. This is probably true with least terns also, and was definitely so in the Bell Island colony. Thus, the 50 birds observed by Coffey may indicate a colony of about 25 pairs. On July 13, 1929, during the height of the nesting season he found 13 nests in the same area.

Mengel noted a colony of 40 or 50 birds at "Kentucky Bend" in Fulton County, Kentucky, on June 13, 1937. He found no nests and it is probable that at that early date no eggs had been laid.

On the upper Missouri River in Iowa, Stiles (1939) found that terns nested in small colonies of 10 to 12 pairs. In nearby South Dakota, Visher (1915) states that colonies of 7 to 8 pairs are the rule on the Vermilion River near its mouth.

In the plains region the colonies are generally smaller. Wycoff (1930) notes that a ternery at Lexington, Nebraska, on the Platte River, never contained more than six pairs in 12 years of observation. Benckeser (1948) observed a colony of five pairs on the South Platte River in Keith County. Tout (1947) in 1928 and 1929 found from 17 to 22 nests in terneries at North Platte, Nebraska, at the junction of the North and South Platte Rivers. These are unusually large colonies judging from other records from that state. Long (1940) lists a colony of five pairs at Coolidge in Hamilton County, Kansas, on the Arkansas River.

On the Red River at Shreveport, Louisiana, Jeter discovered three nests and saw about 20 birds on July 1, 1950.

In the Bell Island ternery there were between 55 and 65 birds present at the height of the nesting seasons of 1952 and 1953. On June 25, 1953, in mid-afternoon, the writer was able to count 28 incubating birds from the blind. It is probable that some birds were not at their nests, and not all nests could be seen from the blind. Thus, it is known that there were at least 30 nests here. This coincides closely with the number of adults counted on several occasions when the whole group was in the air chasing a crow or vulture which had ventured too near the

ternery (see the section on social activities).

The Bell Island ternery is one of the largest, if not the largest, of the interior least tern colonies in existence. In published literature or in the personal correspondence of various workers with the writer, no larger terneries have been reported.

Distribution of the birds in the ternery. Least terns, unlike other closely related species, characteristically do not nest in compact groups. Weiden reports an exception to this in the discovery of 14 pairs nesting in an area of not more than one-quarter acre at Rosedale, Mississippi. Stiles (1939) states that in Iowa, the birds' nests are well scattered--often as much as 50 yards apart. Wycoff (1950) reported a maximum of six nests in an area 75 by 125 feet at Lexington, Nebraska.

The Bell Island sandbar is approximately 120 acres in area. Terns could have conceivably nested anywhere on this area with little danger from flood waters. The ternery was distributed over an area of about 38 acres, giving a density of about .7 nests per acre. The figure does not give an accurate picture of the distribution of nests, however, for generally speaking they were located in groups of five to ten somewhat closer together than indicated. During the first part of the summer study the writer observed a semi-circle of seven nests spaced an average of 14 feet apart.

Nests are usually located well back from the water. Ganier (1930) states that a colony near Tiptonville, Tennessee, on the Mississippi River was several hundred feet from the water and well out from the willows. At Bell Island the ternery was in no danger of minor water fluctuations and was a minimum of 66 yards from the water.

The terns probably prefer those parts of the sandbars with a surface

of gravel and very coarse sand on which to nest. There are indications from the writings of some observers that gravel is not required, for they speak of the eggs being deposited directly on the sand. Wycoff notes at Lexington, Nebraska, that terns actually prefer the fine sand to the gravel. He also observed terns nesting on areas thickly covered with seedling cottonwoods from six inches to a foot high! This is apparently unprecedented. According to Wycoff the terns had nested on the bar for some years and their "dislike" for the vegetation was possibly overcome by their attachment to that particular bar.

At Bell Island the writer found only five nests in sand. Figure 16 shows the gravel areas (shaded portions of the bar) on which the terns nested. The gravel accumulation formed a large oblate ring (see Figure 17) which was the approximate outer boundary of the ternery and the area of greatest concentration of nests.

Figure 16. Shaded areas of the bar are gravel accumulations on which most of the terns' nests were located.

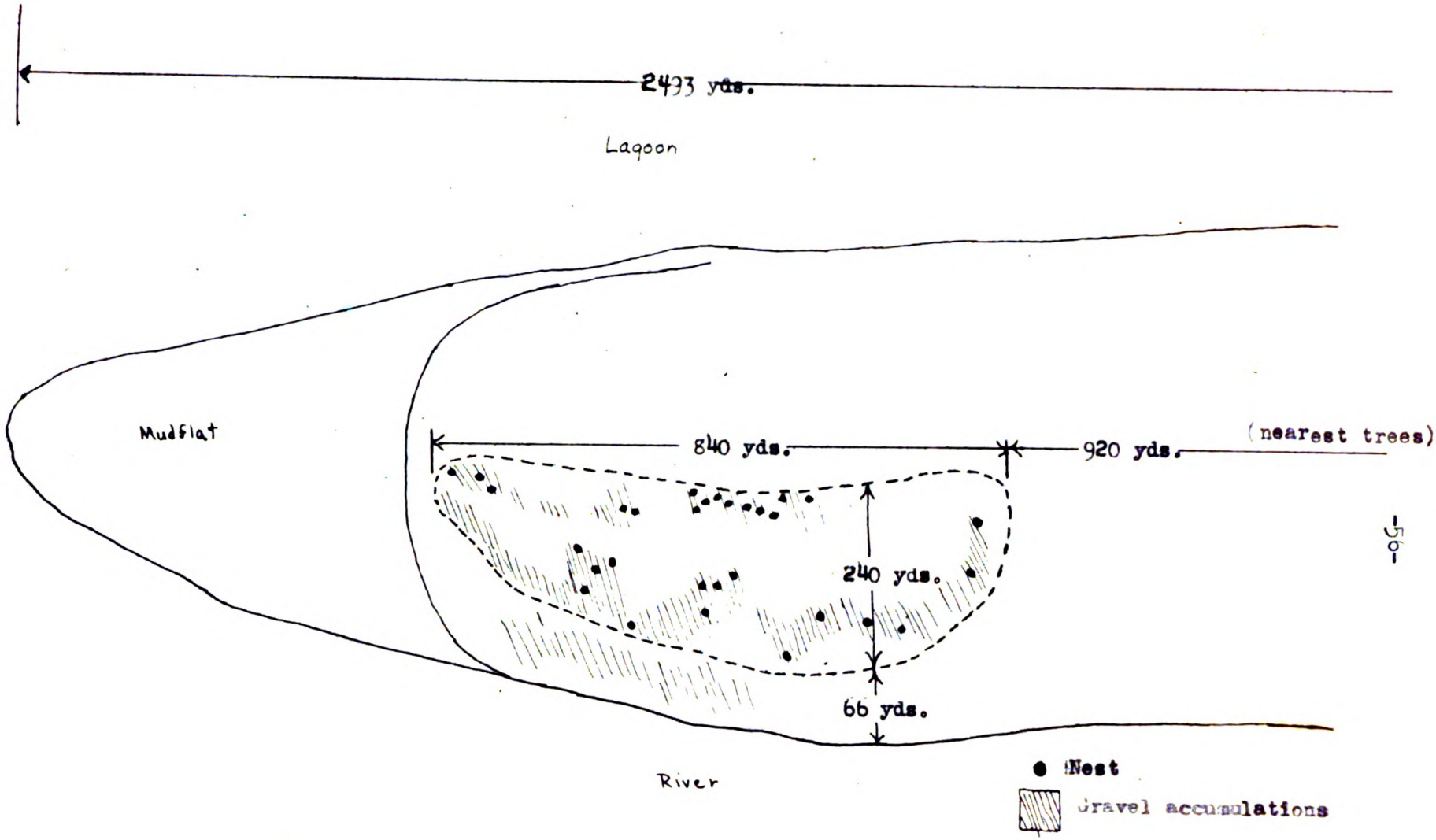


Figure 17 Diagram of nest distribution of the interior least tern on Bell Island.

Territory and Defense

It has already been shown that in the interior least tern, unlike such species as the sandwich tern (Thalasseus sandvicensis) and the common tern, individual pairs are widely spaced within the boundaries of the ternery. Because of this, instances of territorial disputes are rare. It is not clear just how far out from the nest the territory extends, since it is defended less strongly at its boundaries than at the nest. From observations at Bell Island the author concluded that territories were so large that the word had little meaning, and disputes of boundaries so rare that even the birds paid little attention to each other. Occasionally a wandering chick and the attending parents would come too near a neighboring nest and would be attacked by the owner. The latter usually walked toward the adult intruder which usually flew quickly, or retreated a safe distance. If the intruder did not fly immediately, the owner would dive at it until it did leave. For the most part, though, a casual observer seeing the ternery from a distance without causing the birds to fly would find it difficult to believe that a colony actually existed on the sand.

The significance of the upward flutter (Palmer, 1941) in relation to territory is uncertain. In it two birds rise in the air almost vertically with tails spread and bills open. They remain close together and continue so, often to great heights. The Marples (1934) described it as appearing like a quarrel over territory but having an affinity to courtship. Palmer (1941) states that Christoleit noted the flight in Lapwings, and thought the purpose was maintainence of territory.

At Bell Island the writer once observed two birds engaged in the flutter. They came to the ground, the male (?) carrying a little fish

which he gave to the female (?). He then assumed the bent pose with bill and neck extended. Then both took off and began the flutter, rising to 60 or 70 feet, after which they sailed away from each other. All the while they called kibik, kibik, kibik. The fish presentation indicated that these birds were in courtship, and if so then perhaps the flutter is connected with courtship or maintaining the sexual bond. Its discussion is included here since it is referred to by some authors as a part of territorial defense. Observations of the act at Bell Island were certainly not frequent enough to warrant definite conclusions to the contrary.

The Nest

Comparison with other tern nests. The distribution of nests in the ternery has been discussed. As already stated they are more often on gravel or coarse sand, less often on fine sand. Of all terns, the least tern constructs the simplest nest, which is merely a shallow depression in the sand or gravel with no twigs or other materials. Bent (1947), however, states that on beaches where shells are present least terns may use them to encircle their scrapes. This is in contrast to the more elaborate nests of the common and roseate terns which often build platforms of grass and sticks when these are available near the nest.

Initiation of nest-building. Incipient nest or scrape-making begins as a phase of courtship. At this time both adults engage in nest-making to such an extent that the depressions fairly cover the ternery grounds. Males usually make the first scrapes and are then followed by the females which are stimulated by the sight of the hollows made by the males. The Marples (1934) found that shoe prints stimulated terns to

make scrapes of them. At Bell Island terns occasionally transformed the writer's boot prints into temporary nests when the young birds wandered from the original scrape.

Method of scrape-making. It takes a very short time for a least tern to scoop out a nest hollow. The bird leans forward, nearly touching its breast to the ground, and bracing with one foot, kicks the sand backward with the other until a depression is made. To mold it to the body form it nestles in the depression and wallows from side to side until satisfied that the scrape is suitable.

Description of the nest hollow. At Bell Island the writer took measurements of six nests located near the blind. Their average diameters were as follows:

	Approximate Diameter
Nest A	130 mm.
Nest B	140 mm.
Nest C	82 mm.
Nest D	140 mm.
Nest E	100 mm.
Nest F	120 mm.

Nest C came nearest to being no scrape at all. The others were all well defined with a depth of about 1 to 2 cm. and were nearly circular in outline. Figures 18 and 19 illustrate two nest hollows, one in sand, the other in gravel.

Use of the nest hollows. Scrapes were not only used to hold eggs and young, but as soon as the young were able to walk and began to wander across the sand, the parents followed them, hurriedly constructing temporary hollows in which to brood the chicks until they moved again.

Figure 18. A typical interior least tern nest at Bell Island. Note that the scrape is on a gravel area.

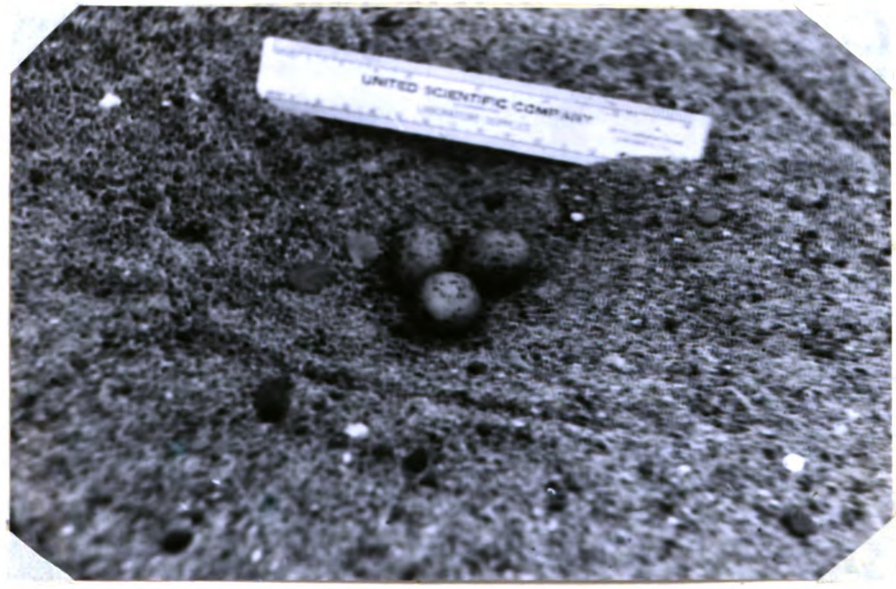


Figure 19. A nest of the interior least tern at Bell Island. This scrape is in the finer sand used only rarely by the birds in nesting.

The Eggs

Size of the eggs. Measurements were taken of 17 eggs from the clutches in the six nests near the blind. They averaged 31.2 X 23.8 mm. This agrees closely with the average given by Bent (1947) and the Marples (1934). The measurements of the 17 eggs are given in table III. No differences in size which could be correlated with variable factors in the environment were noted.

Color of the eggs. The ground color varied from pale buff to olive buff, specked and streaked with dark purple-brown to chocolate and blue-gray. Figures 18 and 19 show two typical clutches of the interior least tern at Bell Island.

Size of the clutch. The size of the clutch of the interior least tern varies from one to four, but is usually two or three. There is apparently a tendency toward 3-egg clutches in the north to 2-egg clutches in the south. In the plains area two and three egg clutches are about equal in occurrence.

Vaiden states that at Rosedale, Mississippi, two eggs is the probable clutch in over 95 per cent of the nests. He further states that while three eggs in a clutch is rare, one occasionally forms the full complement. In the central part of the terns' range there is much variation in clutch size. Coffey (Ganier, 1930) noted one group of 13 nests on Middle Bar at Memphis, Tennessee, in which one contained three eggs, seven held two, and five held one. At Bell Island the writer estimated that about 80 per cent of the nests contained three eggs, about 20 per cent two. In Iowa, Stiles (1939) states that the normal clutch is three eggs, although one and two occasionally form the full complement. At Omaha, Nebraska, Moser (1940) found two and three egg clutches about

equal in occurrence. Tout (1947) recorded differences in average clutch size in different years at North Platte, Nebraska. In 1926 he noted 10 nests of which three held one egg, six held three, and one held four. In 1928 he found 18 nests, of which one held four eggs, one a chick and an egg, three held three, eleven held two, and the rest held one. Table II summarizes clutch sizes from selected stations throughout the interior least terns' range.

Table II CLUTCH SIZES OF THE INTERIOR LEAST TERN

Size	Rosedale	Memphis	Bell Island	Sioux City	Omaha	North Platte
	Number of Nests containing a given clutch					
4	none	none	none	none	none	2
3	very rare	1	9 (24)**	very common	3	12
2	95%	14	1 (6)**	uncommon	3	9
1	4% (est.)	7*	0	uncommon	0	2

*some of these were probably incomplete clutches.

**number in parenthesis indicates approximate figure for entire tern-ery.

Infertility of eggs. Palmer (1941), working on common terns, and Pettingill (1939), working on arctic terns (Sterna paradisea), found that infertility of eggs ran between five and six per cent. In contrast, Austin (1929) found that in a total of 17,500 eggs laid in the common tern colonies at Cape Cod only one in 500 was infertile.

At Bell Island all eggs which did not hatch, such as those known to have been deserted and those in nests where other chicks had hatched at least three or four days before, were opened. Only three of these were found to be infertile. Two of the eggs were in the same nest. All others which were opened had chick embryos in various stages of develop-

ment. The apparent infertility was about 3.6 per cent (assuming that there was a total of 84 eggs in the colony). These percentages will be discussed further under the section on mortality.

Table III EGG DATA FOR SIX NESTS AT BELL ISLAND

Nest	Clutch Size	Egg Measurements in Millimeters
A	2	33 x 24; 31 x 24
B	3	30 x 23; 31 x 23; 32 x 23
C	3	29 x 24; 29 x 23; 30 x 24
D	3	31 x 23; 29 x 23; 30 x 25
E	3	34 x 26; 31 x 24; 31 x 24
F	3	33 x 23; 33 x 24; 32 x 25

Egg-laying. Hagar (1937) found in a study of the least tern on the Massachusetts coast that eggs were laid at intervals of two days. Witherby (1941) states that with the least tern in England, eggs are laid on consecutive days. Coffey noted in a colony at Memphis, Tennessee, that eggs were usually laid every other day. Moser's (1940) observations from Omaha, Nebraska, would indicate that the eggs are laid every other day. The writer did not arrive in the Bell Island ternery in time to gather any data on egg-laying. However, it seems probable that eggs were laid on consecutive days, since in all cases observed the eggs hatched on consecutive days.

Incubation

Initiation of incubation. Witherby (1941) states that in England incubation begins when the second egg is laid or earlier. At Bell Island incubation probably began soon after the first egg was laid, since, as already noted, eggs hatched on consecutive days.

Hagar (1937) writes that in Massachusetts adults losing their nests

and eggs during the incubation period usually renest in about three weeks. At Bell Island this was not the case. From the height of the incubation season on there was a gradual reduction in the size of the population and number of nests. This probably resulted from eggs being lost from predation, or other unknown causes. From daily checks on the number of birds remaining in the ternery, it was fairly certain that none of these birds renested, at least at Bell Island.

Length of the incubation period. At Bell Island, the writer arrived so late that most of the egg-laying had been completed so that no accurate data on length of incubation are available from there. The length of the period in least terns has been much disputed. Vaiden believes it to be from 18 to 22 days at Rosedale, Mississippi, and computes this from the date of the first egg laid to the date of the first egg hatched (see Worth, 1940). Moser (1940) found that the period was 18 days at Omaha. Nagar (1937) gives 19 to 24 days for Massachusetts. The Marples (1934) state that it is 20 days in England.

At Bell Island the first egg hatched on June 30. With an incubation period of about 20 days, this would indicate that the first egg was laid on about June 10. Since it has been shown that the bar first became exposed about June 4, the June 10 date is at least near the beginning of egg-laying. Since the greater part of hatching occurred during the week following June 30, then the principal period of egg-laying was probably from June 10 to June 17. Very little laying occurred after June 17, since the last chick, so far as known, hatched on July 10.

Activities during incubation. Witherby (1941) states that with the least tern in England incubation during the first few days is performed wholly by the female. Later on the male gradually assumes a share of

the duty.

In the Bell Island ternery there was much variation in the relative participation of the parent birds in incubation. Different pairs employed different methods. Basically, these routines were separable into the three following types: (1) nearly equal division of incubation duties with the male seldom feeding the female on the nest, and alternation of incubating and feeding for each adult, varying from a few minutes to an hour or more between change-overs; (2) female performing most of the incubation with the male usually not feeding her on the nest but "guarding" the nest or incubating for a short time while she is feeding; (3) female performing most of the incubation with the male feeding her regularly on the nest. From casual observation, the first method seemed to be the most prevalent, the last was next most common, and the second the least employed among all terns in the colony.

Figure 20, part a, shows the degree of attentiveness of pair D during incubation. The following observations are from the author's notes for that period and describe the activities taking place at nest D.

June 24. A.M.

8:00 Adult (probably female) incubates.

8:02 She flies from the nest crying kee-dip, kee-dip in answer to another bird flying over. Twice I have noted birds flying past with fish. As the bird does so all terns in vicinity give this kee-dip call with much other chatter.

8:03 Female returns to the nest, probably from pursuit of a vulture.

8:05 Leaves again.

8:11 An adult, probably the same one, returns to nest.

8:12 An adult, probably the male, comes to the nest and stands nearby while female continues to incubate.

8:15 Female flies and male continues to stand by.

8:20 Male finally incubates after standing near nest for 8 minutes.

8:22 He leaves nest calling kee-dip, kee-dip.

8:23 He circles once and returns to incubate.

8:31 After 10 minutes of incubation male leaves to grui grui call of flying bird which soon hovers at about 50 feet over the nest and finally lands about five feet from it, walks to the nest and incubates. This is probably the female.

8:50 Female still incubates.

9:00 All birds in the group fly "kee-dipping" away. A crow or vulture is the reason.

9:02 A bird returns to incubate at D. Probably the same one.

9:09 A general upflight occurs as a human approaches.

9:12 Birds all return to nests. Probably still female at D.

9:50 Female still incubates unless there was a change at the last upflight.

9:51 Upflight as birds all pursue a crow across ternery.

9:52 They return to their nests.

During the 120 minutes of observation the eggs were incubated approximately 100 minutes or 83 per cent of the time. The male incubated only 10 minutes or 12 per cent of the total time of incubation, the female incubated 90 minutes or 88 per cent of the time of incubation.

A notable feature of the preceding account is the number of upflights that occurred. The terns seldom incubated with ease and were put to flight at the slightest provocation. The most prominent cause of these flights was the venturing of a turkey vulture (Cathartes aura)

or crow (Corvus brachyrhynchos) too near the ternery. Flights were also caused by boats on the river. For some reason the big steamers seemed to attract the terns, and they often flew to the vessels and "accompanied" them for short distances.

In another observation of attentiveness at nest D the female incubated from 9:49 until 11:18 (89 minutes) with only two flights to the lagoon to "dip" in the water. The male was not present during this entire period. At 11:18 he assumed the incubation duties for nine minutes until 11:27 while the female fed and "dipped" in the lagoon. Figure 21 shows the female of D incubating during one of her long periods of duty.

At Nest E the female, as already stated, performed most of the task of incubation with the male feeding her frequently on the nest. Figure 20, part b, illustrates the degree of attentiveness of each bird and denotes the feedings. The following account is taken from the writer's field notes and describes the same period shown by the figure.

June 26. A.M.

9:45 The female incubates.

10:03 The male comes to the incubating bird calling keedee-cui, keedee-cui very rapidly. The female answers with a "yellow-legs-like," two-syllabled note. The male carries a fish which he offers to the female which takes it and quickly eats it. As she does so the male postures with head erect, bill pointed up at a 45° angle, neck stretched outward, and wings halfway elevated and open. (Figure 22 illustrates the beginning of this posturing display.) The male then flies, giving the keedee-cui call.

10:05 The feeding is repeated with the routine being identical to the first feeding.

10:07 Female leaves the nest calling kibick.

10:08 Returns.

10:21 Another feeding after 16 minutes.

10:25 Again the male feeds female.

10:38 Same.

10:45 Same.

10:50 After another feeding at E both adults fly, but the female returns to incubate at 10:51.

10:57 Male feeds female who leaves nest and walks to meet him about a yard from it.

11:04 Again she leaves nest to get the fish.

11:12 Feeding, using the original routine.

11:25 Female leaves nest to chase a Kingbird which perches on a log nearby.

11:26 Male feeds female on nest.

11:30 An upflight occurs in the ternery after a crow.

11:31 Female returns to nest.

11:35 Male feeds female on nest.

12:00 Female incubates.

During the 135 minutes of observation of nest E the female left the nest six times for a total of six minutes. She thus incubated for 95.5 per cent of the total time. The male fed the female 12 times at the nest, an average of one feeding every 11.2 minutes.

The posturing display noted at nest E when the male fed the female was commonly observed at feedings and in change-overs at other nests. The male of E was observed to posture even though he had come to the nest without a fish. The posturing which occurs in fish presentation in courtship is identical to this so far as the writer was able to observe.

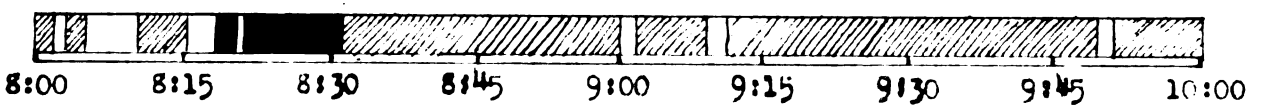
Terns which remain on the nest for long periods of time often make brief excursions to the river to "dip." This no doubt is because of

the high temperature of the sand which causes the bird discomfort. Mabbett (1890) observed that least tern eggs on the lower Mississippi River bars often had small drops of water on the shells. The answer to this seems to be that the adult tern sprinkles water on the eggs when returning from the river. The birds often hover a few feet over the nest before alighting, and doubtless droplets are shed from the wings and body onto the eggs.

At Bell Island a tern coming to the nest came directly to it if the other bird were at the nest. Occasionally the incubating bird flew before the arriving bird was near so that the latter was temporarily thwarted and hovered uncertainly for a few seconds, obviously searching for the eggs. This would indicate that the bird recognized the nest area but had no idea where the actual nest site was located until it saw the eggs.

Nest D
June 24, 1953

Part a



Time of female on nest: 90 min.
Time of male on nest: 10 min.
Time both birds off nest: 20 min.

Female incubates
Male incubates
No incubation

Nest E
June 26, 1953

Part b

Time of female on nest: 129 min.
Time of male on nest: none
Number of feedings of female by male: 12

Female incubates
No incubation
Male feeds female

Figure 20. Records of attentive and inattentive periods at two nests during incubation.

Figure 21. The female of nest D during incubation.

Figure 22. The male of nest E immediately after giving the female a fish. The wings are upraised in the beginning of the posturing display.

Hatching

At Bell Island the first egg hatched in mid-afternoon on June 30. It was not noticably pipped during the morning check of the nests. A close inspection of another egg in the same nest at the time the hatching was noted showed that it was pipped. It hatched in late afternoon of July 1, nearly 24 hours later. Palmer (1941) states that common tern eggs may be pipped as much as 36 hours previous to hatching. Hatching did not occur in the Bell Island ternery at any particular time of day. Several eggs were known to have hatched either at night or very early in the morning.

On emergence the young tern is still wet and weak, but is able to utter a faint rasping, peeping note audible only a few feet away. It is unable to stand and lies resting on its tarsi (see Figure 23). The intense heat dries out the natal down in a few hours and there is an accompanying increase in activity. The chick is still not able to stand fully upright but seeks shelter from the sun within the scrape by crawling slowly about.

Growth and Development

Figure 27 illustrates the growth of the young least tern and represents a "typical" development from data on 20 chicks. No chick was observed throughout its growth to flight stage; indeed, very few were watched for over four or five days of this period, since they wandered freely over the sandbar by the second day after hatching and were very difficult to locate. Thus, there are large gaps in weight and plumage data. However, the writer has attempted to present a general description of development even in those periods where descriptions are not positive-supported by chicks of known age. Such is the case of descriptions of young after the first week of life.

Natal down stage. At birth the interior least tern chick is completely covered with down and weighs 4.9 grams (average of 8). No complete data were kept on growth of the wing bones of very young chicks. The upper and lower arm (humerus and radius-ulna) are approximately 1.5 to 2 centimeters long. These do not change much in the first week of growth. The down is yellow or buff in color, darker on the upper parts and fading to almost pure white on the underparts and sides of the head. Over this the chick is spotted or mottled with dark brown or gray-brown. This pattern is heaviest on the back and becomes sparser and arranged in striations on the head. The eye is dark brown, almost black, the bill dull reddish brown tipped with black, and the feet and legs pink or flesh-colored.

By the end of the second day the chick has gained considerable powers of locomotion. It is able to walk and begins to leave the nest on short excursions. There are periods of great activity, generally in early morning or late evening, and others of drowsiness, usually during mid-day. During the latter period the chick is usually brooded. Figure 24 shows a two-day old chick, Figure 25 from left to right, one, two, and three-day old chicks.

Plumage and color characteristics remain nearly the same during the first week. Weight and growth of appendages increase, the former rapidly at first and then gradually slower, the latter rather slowly. By the sixth day the chick weighs about 16 grams and is about 9 centimeters long (average of two chicks). The wing has increased somewhat in size, particularly the forearm which is now about 3 centimeters long. On about the sixth or seventh day the postnatal molt begins and the first signs of juvenal plumage appear in the form of the primary wing

quills on the alar tracts. These may be as much as 1 centimeter long. Shortly afterwards the secondary quills appear and are about ½ centimeter long.

Pre-flying juvenal stage. Growth of the juvenal plumage is rapid after the first week. At about 10 days feathers are present on the humeral tracts and may be as much as 2 centimeters long. The chick weighs about 21 grams and is about 10 centimeters long (description of a single chick estimated at 10 days of age).

The following description is based on data obtained from three chicks estimated to be from 14 to 16 days old. The chick weighs from 33 to 40 grams and is 12.6 centimeters long. The latter weight is about the average adult size. The wings have assumed adult proportions, having lengthened remarkably. Contributing most to this is the lengthening of the forearm to about 4 centimeters and the growth of the wing feathers. The longest primary is 5.2 centimeters, the longest secondary about 1.5 centimeters. The bird is now almost completely feathered except on the rump and the anterior dorsal surface of the wing. In the youngest of the three chicks the longest primary was 5 centimeters but only open in the distal ½ centimeter. Down persisted on the head and sparingly on the back. The retrices have begun to develop and are about 1 centimeter long. The color is now buff and grey, lighter on the back and shading to slate on the outer primaries. The wing feathers are edged with white and the upper body feathers with buff. The back feathers bear a dark crescent. The bill has also grown from about one centimeter upon emergence of the chick to about two centimeters (length of culmen). The bill is black, the legs are pink and as long as those of the adults (tarsus about 1.3 centimeters), enabling the chick to run swiftly. The

bird is extremely wary and difficult to find or catch. Figure 26 shows a tern about two weeks old.

Flying juvenal stage. The chick flies at about 20 days of age. The plumage is much like that of the two-week-old bird, except that the feathers have developed further. The rectrices are still short, but the wings are nearly adult size. This gives the bird an unbalanced look when in flight. The bill is darker and shorter than in the adult. In general appearance the bird looks not unlike an adult black tern (Chlidonias niger) in the post-nuptial molt. It does not fly long distances or at great heights. Young just learning to fly at Bell Island circled aimlessly at a height of about 20 feet only to alight not far from the starting place. The wing beat was slow and not full as in adult flight. The loose juvenal plumage made them appear larger than their parents.

Figure 23. An interior least tern chick about three hours old.

Figure 24. A two-day old interior least tern chick at Bell Island.

Figure 25. Three interior least tern chicks from the same nest. Left to right they are approximately one, two, and three days old.

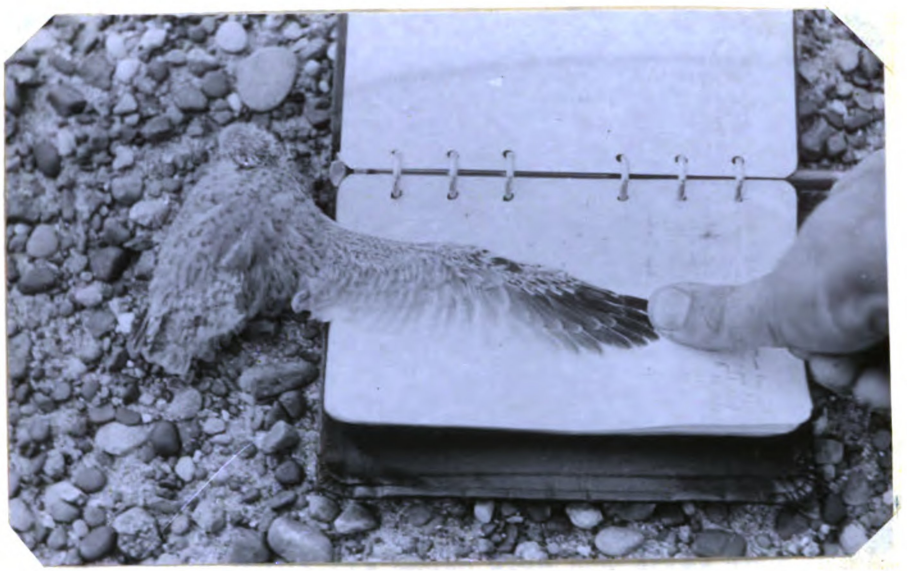


Figure 26. A two-week old interior least tern chick (estimated age) at Bell Island. Note the characteristic crescent marks on the back feathers and the great length of the wing in proportion to the rest of the body.

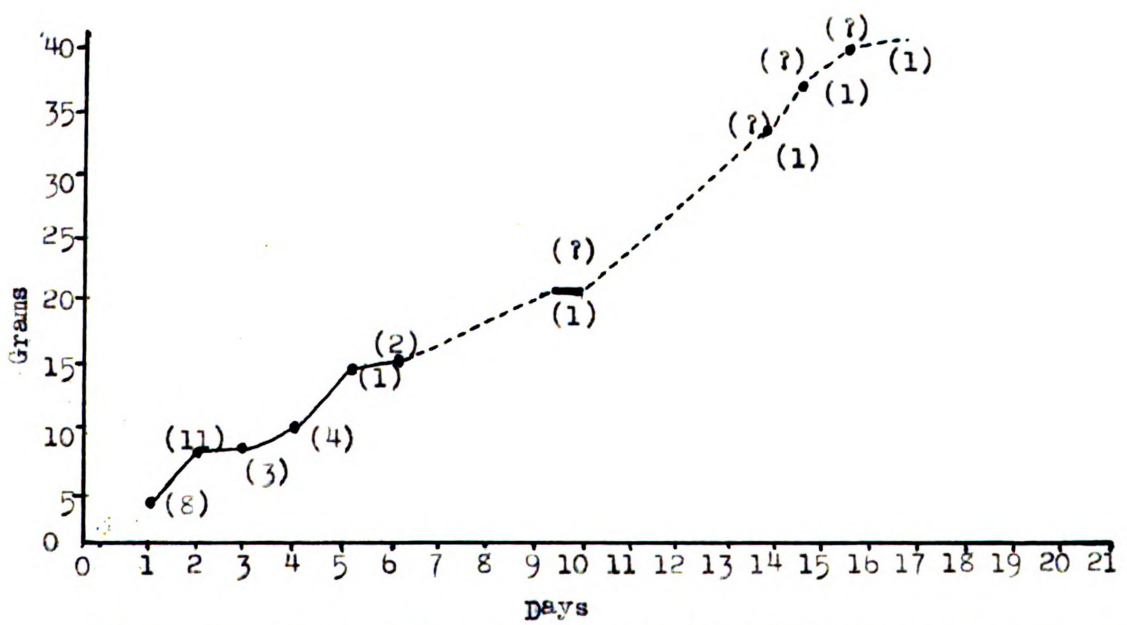


Figure 27. Daily weight increase of interior least tern chicks. Numbers in parentheses indicate number of young averaged for a given age. Question marks indicate that age is estimated.

Care of the Young

Incipient parental behavior. At nest D where the first young of the ternery hatched neither adult was at the nest when the writer first observed the new chick, although one was probably present at the time of hatching. The adults' first reaction to the young was negative. The following description of the behavior soon after hatching at nest D is from the author's field notes.

June 30 (P.M.)

5:45 The newly hatched young (about three hours old I estimate) raises up and even walks a short distance around the nest. It occasionally opens its mouth wide and cries in a harsh two-noted call--not unlike the beginning notes of the grasshopper sparrow's (Ammodramus savannarum) song. The female (?) parent is extremely wary and flies back and forth overhead.

5:50 The female comes to the nest and stands several feet from it, then flies away. This is repeated several times.

6:00 She alights about six feet from the nest. Until now I have noted no reaction of the young to adults or their call notes, but now it staggers toward the female with wings up. The adult appears not to recognize the chick as such but stares at it warily. As the young nears the adult the latter walks quickly past it and stops again. She utters a subdued grui grui, and after several seconds goes to the nest and incubates the eggs. The young rests about three feet away. Presently the young walks to the nest. The female calls grui grui and watches the chick, which noses beneath her. She raises slightly permitting it to crawl into the scrape. She soon flies again.

6:05 The routine just described is repeated.

6:20 The female has brooded for about 12 minutes when both adults suddenly seem to "recognize" the chick, and the male comes with an extremely small fish. He calls keelee cui with the female answering from the nest. He offers the fish to the chick which has emerged from beneath the female in response to the cry of the adults. The chick takes the fish from the male and stands holding it with head bent and fish cross-wise in the bill, then feebly juggles the morsel and quickly swallows it. The chick then hurriedly crawls beneath the female.

During the period of observation until 7:20 the adults attempted to feed the chick five times, or once every 12 minutes. The same routine was enacted each time except that the chick did not crawl beneath the female each time but lay beside her. On the fifth feeding it merely pecked at the fish and would not eat it.

From these observations it would seem that the sudden "recognition" and subsequent feeding of the young bird represents a change from instinctive incubation reactions to instinctive care of the young. Apparently a certain amount of "conditioning" was necessary before feeding was commenced.

The female D became much less wary after feeding of the young began. The period of wariness and anxiousness was probably a result of being divided between two possible reactions (to the eggs or the young) which could not be responded to at the same time.

The egg shell was not noted in the above nest so that it was probably carried away as soon as the young hatched. One marked shell was later found about 200 feet from the nest from which it came.

Terns are apparently able to select the size of fish which they catch. In feeding the female, the male always brought minnows from one to two inches long. The young were fed small fry less than an inch long for the first few days, then gradually were offered larger ones.

Brooding at the nest. Prolonged brooding of the nestlings takes place only during the first few days after hatching--usually the first two days. This is because the young begin to wander from the nest, and except in the extreme heat of mid-day are not brooded during daylight hours.

The writer experienced much difficulty in keeping the first chicks in the nests until the other eggs had hatched, so that studies of feeding, brooding and growth of chicks could be made. In order to confine them temporarily to the nest a small pen was constructed around the scrape. This was about 6 inches high and about 18 inches square. Palmer (1941) found this method useful with common terns. The pen was used with only one nest, since it was felt that it altered the normal actions of the birds. The natural procedure could thus be observed in those birds not penned up, and information could be conveniently gathered on feeding and brooding activities, since it was obviously impractical to follow chicks across the sand with the blind. (See Figure 29 for an illustration of the pen.)

Participation, behavior, and the brooding rhythm. Figure 23 gives a record of attentiveness of a pair of least terns with three young, one, two, and three days old, respectively. Time spent in brooding by the male and female was about as in incubation, that is, the female performed most of it. Figure 23 shows that the male's periods were short. He brooded restlessly and often made brief excursions to the water or

around the bar for no apparent reason, leaving the young unattended. Usually the male's total brooding time was only long enough to allow the female to fish or bathe briefly and return to the nest. Figure 28 gives the total and average time of brooding for each parent.

Temperatures were cool in early morning and late evening, and though the female made some effort to brood the young then, they avoided her and spent their time scurrying about in the nest area. By 8:00 a.m. sand surface temperature began to increase (during the first week in July it usually reached 90° to 100° by that time), and the young became less active, seeking shelter from the sun by crawling beneath the parent. Figure 28 shows that by about 8:40 brooding became almost constant and continued into mid-day. It usually lasted until nearly dusk on the warmest days and continued intermittently through the day on overcast or cool days of which there were very few. Figure 30 shows a female alighting to brood. Chicks not brooded during severe temperatures usually suffered greatly, although the writer noted no deaths directly attributable to heat. As already stated, while marking and weighing young, they occasionally sought shelter by running up the observer's trouser leg.

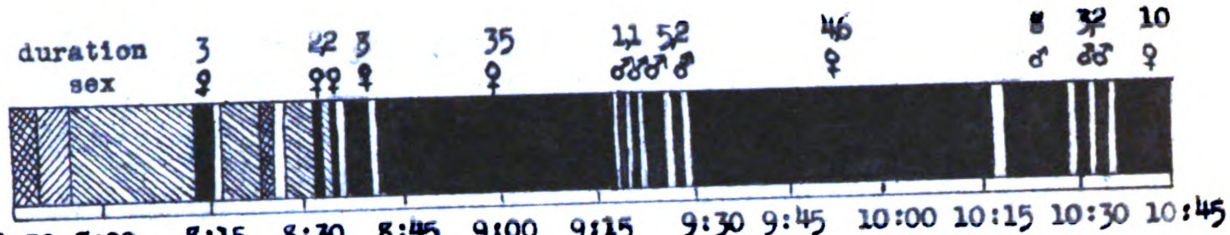


Figure 28. A record of attentiveness and brooding. Observations were made on July 10. The day was clear with a high of about 90° and a wind velocity of 10 m.p.h.

Total time of observation: 195 min.
Total time of female brooding: 97 min. (29.84 min./hr.)
Average length of female brooding period: 13.71 min.
Shortest period: 2 min.
longest period: 8 min.

Total time of male brooding: 32 min. (10.68 min./hr.)
Average length of male brooding period: 8 min.
Shortest period: 1 min.
Longest period: 8 min.

Female attentive, not brooding
Male attentive, not brooding
Brooding adult (see graph for sex and duration of each period.)

Feeding at the nest. As in the case of brooding, feeding in the nest occurred only during the first two or three days. Both sexes participated about equally in feeding, but since it was often impossible to distinguish positively the male from the female, exact data cannot be presented on comparative participation.

It was found that in one pair in 20 attempted feedings the supposed male visited the nest 9 times, the female 11. Table IV summarizes the feeding activities in two pairs of terns. The first column is for the same period discussed in the section on Incipient parental behavior. The second column presents feeding data for the same observation period discussed in the section on Brooding in the nest.

It is apparent that even though the female brooded over three times as long as the male, she also made more attempted feedings.

Feeding time was correlated with brooding time. During the early morning hours of great activity, the young refused to be fed. The adults made four unsuccessful attempted feedings between 7:30 and 8:00. From about 8:30 until 10:45 (the end of observation) when brooding was almost continuous, only four offerings of food were refused, and these were because hunger had been satisfied, or in one case because the adult would not release the fish to the chick even though the latter was eager to accept it. In the evening, feeding gradually ceased toward dusk.

By the second day the chick usually recognized the parent even before it came to the nest. This was probably because of the call note of the adult, since often the chick was beneath the parent and could not have seen the flying bird. Adults learned to recognize their young at about the same time. When the chick wandered away in their absence they were able to go directly to it. They never mistook other chicks for their own.

Adults were stimulated to feed by the actions of the chicks. Several times a young bird was observed to run with mouth open to an adult which had no fish but which nevertheless went through the act of feeding the chick. Palmer (1941) states that in common terns the stimulation is brought about by the young pecking the bill of the adult.

So far as the observer could determine, all chicks received about the same amount of food. They seldom took more than they could eat and were usually satisfied for several feeding visits afterwards. Consequently the smaller chicks got their share, even though the larger chick might have had the food if it had wanted it, simply through superior strength. On some occasions the adult was noted to offer the fish to the youngest chick first. It is difficult to say whether this was an attempt on the part of the parent to distribute the food equally.

In all cases observed feeding was direct, from the adult which had brought the fish to the chick. If the chick dropped the food it could not pick it up. The adult either continued to pick up the fish and offer it to the young or refused to feed after the first attempt. If no chick wanted the fish the adult either ate it or, in the case of the male, gave it to the female. Rarely, it would keep the fish and fly a short distance only to return and try to feed again. Often this second attempt was successful, even though only seconds had elapsed since the unsuccessful attempt.

Figure 29. A pen around a tern nest confines the chicks so that they can be studied. Note the white blur of an adult bird as it swoops at the observer.

Figure 30. A female interior least tern alighting at her nest on Bell Island. Note the brood patch.

Care of the pre-flying juvenal. As stated previously, least tern chicks began to wander from the nest by the second day and usually did not return thereafter. Contributing to this was the fact that, in contrast to the common tern, adult least terns cared for the chicks not only at the nest, but followed them across the sand, brooding them in temporary scrapes and feeding them wherever they might be.

Moser (1940) noted in observations of the interior race at Omaha, Nebraska, that from a distance with a field glass the young could be seen running across the sand in some numbers, and that they began these excursions within 48 hours after hatching.

At Bell Island the chicks at times seemed to have a very definite destination in mind after leaving the scrape. Those in nests near the middle of the bar nearly always headed for the lagoon side of the ternery, while those in nests near the mainstream side of the bar always ran to that shore.

The adults, although they seemed distressed at these wanderings, were unable to prevent them. The observer twice saw a parent bird evidently trying to make a chick lie still. The adult alighted beside the young bird which was scurrying across the sand, and seizing the chick in its bill hurled it to the ground. The chick appeared to be dead, but no sooner had the adult departed than it was up and running again.

No exact data could be obtained on feeding and brooding from the rather confused situation resulting from these wanderings, but in general it can be said that both activities were irregular, since as often as not the three chicks in a nest would scatter in three different directions so that the adults were kept busy trying to care for them at all.

A harmful result of this nest desertion was the resultant neglect of eggs still remaining in the nest. As long as the young remained in the nest the eggs still not hatched continued to receive incubation. Yet once the interest of the adults in the chicks had been aroused they seemed to neglect any remaining eggs, and never resumed incubation once the first born chicks had deserted the scrape. The writer noted several single eggs in the ternery which failed to hatch for this reason. On opening them they proved to have dead embryos not more than two days from hatching.

During the week previous to the beginning of the flight stage most of the chicks which had survived after deserting the nest had gathered on the shelf of the Bell Island bar near its outer end. Here they could be found crouched between pieces of driftwood or under the leaves of a few small herbs which grew there. They were fed here until able to fly.

TABLE IV. A SUMMARY OF FEEDING ACTIVITIES AT TWO NESTS.

Age of Nestlings	3 hr.	1,2, and 3 days.
Period of Observation	5:45-7:20 p.m. (1 hr. 35 min.)	7:30-10:45 a.m. (3 hr. 15 min.)
No. of Nestlings	1	3
Total feeding visits	5	20
Average no. feeding visits/hr.	3.15	6.1
No. successful feedings	4	12
Average successful feedings/hr.	2.52	3.6
No. intervals between successful feedings	3	12
Average length of interval	3 plus min.	14.58 min.
Extremes	2-5 min.	1-48 min.
Feeding attempts by (assumed) male	5 (all)	9
(assumed) female	-	11

MORTALITY AND LONGEVITY

Mortality

Mortality in least terns is extremely high up to the flying stage. Hager (1937) stated that in a colony of 423 nests in Massachusetts, 308 (72 per cent) were lost before hatching. Of the 820 eggs only 212 (26 per cent) hatched. Of these 212 chicks, 75 reached flying stage, a survival of only 9 per cent.

At Bell Island during the 1933 season, mortality was even higher with only two young positively known to have reached flying stage. The approximate survival rate was estimated by the writer as follows. Assuming that the colony contained 30 nests, there was a potential of about 84 eggs. In seven nests under close observation 13 of 20 eggs hatched (65 per cent). Applying this percentage to the colony as a whole, approximately 55 young should have been hatched. During the pre-flying juvenal phase (the third week in July) 8 young were known to be alive. Yet, on July 21 only 2 could be found, and these were both flying birds. Several hours watching from the blind and a thorough search of the bar revealed no other chicks, and it is believed that there were none. This is a survival of only 1.7 per cent.

Apparently the season was an unusual one. At one period, between July 5 and 8, all the chicks banded from the nests under observation disappeared. The cause of their disappearance is not known.

Longevity

High mortality in the natal and juvenal stages is balanced by a low mortality in adult terns. Tomkins (1934) in Georgia recorded a 10-year-old least tern banded in 1923 and recovered in 1933. The Murphys (1934),

assuming that the least tern in England lived an average of five years (no exact reason given for this assumption), and that they laid an average of 2.2 eggs (average of many clutches), reasoned that a female tern laid 11 eggs during her life. Only two of these would have to hatch to maintain the species. Thus, a mortality of over 70 per cent could be tolerated.

Causal Factors

Causes of mortality at Bell Island have been mentioned in many places in the preceding sections, but to summarize they probably included infertility of the eggs, desertion of the eggs resulting from the first hatched chicks leaving the nest, parental neglect, exposure to the sun, and predation. In many colonies floods take a heavy toll, especially on the low bars in the plains area. It was impossible in the short time spent in this study to determine the relative importance of these factors, but parental neglect seemed to be a basic one.

RELATIONS OF THE TERNS WITH OTHER ANIMAL SPECIES

Associates

Unlike other closely related species, the least tern characteristically nests only in homogeneous groups, even when other species are nesting in the same region. However, the interior least tern in some cases nests with the piping plover (Charadrius melodus) and the snowy plover (Charadrius alexandrinus). The former is an associate of the tern in Nebraska, the latter in northwestern Oklahoma where the two can be found nesting on the salt flats.

Moser (1943) states that least terns and piping plovers, although usually nesting in separate groups within a large area of sand, in 1943 used the same site because of encroaching vegetation on a part of the bar. Wycoff states that at Lexington, Nebraska, he has found terns nesting with the plovers, but that the nests are usually separate because the terns prefer finer sand and gravel than the plovers.

At Bell Island no other species nested on the bar. The most common species frequenting the bar was the bank swallow (Riparia riparia) which came to feed on insects on the sand in flocks of as many as 150 birds from a colony of perhaps 200 pairs which nested in a large clay bank directly opposite Bell Island on the Kentucky side. Other species which occasionally entered the ternery were the killdeer (Charadrius vociferus) and kingbird (Tyrannus tyrannus). The terns for the most part ignored these visitors even though the bank swallows occasionally landed in great swarms among the tern nests in search of small beetles. A tern was once observed to chase a kingbird which ventured too near its nest.

Predators

Rats are frequent predators in common tern colonies along coastal regions (Austin, 1948), as are various species of gulls and jaegers. Bartsch (Sprunt, 1948) observed young least terns being mutilated by having their wings clipped off by sand-crabs. At Bell Island no predation was ever actually observed, yet instances of eggs missing from nests overnight and the mutilated bodies of several chicks, on one of which only the legs remained, seemed to indicate that some predation existed. Most probable predators were the crow,, black vulture (Coragyps atratus), turkey vulture, and the black-crowned night heron (Nycticorax nycticorax). Judging from the actions of the terns toward the first three, they were predaceous on the ternery. The heron probably was a night visitor to the colony. Marshall (1942) states that this species eats the eggs in common tern colonies on western Lake Erie at night. At Bell Island the species was not common, but on several evenings just before darkness two or three of them frequently came to the shore of the sandbar to feed. The writer once observed an opossum walking along the beach. Other mammals may have been present but their tracks were never seen in the ternery. The vultures loitered along the beach during the day and occasionally flew low over the ternery. They were never seen to alight near the nests, although on one occasion one did perch on a log near the edge of the ternery and seemed to be searching for something, all the while being "bombarded" by the terns.

Relations with Man

The least tern is of little economic importance in most of its range. However, Gates reported that at a fish hatchery near North Platte,

Nebraska, the birds are shot because they feed on the small fish in rearing ponds. At Bell Island the birds are little known by the natives who refer to them as "minner hawks," in reference to their feeding habits.

SOCIAL ACTIVITIES

Fishing

At Bell Island least terns fished almost entirely in the shallow littoral waters of the bar which were primarily on the mainstream side and in the mud-flat point area. There was some feeding in the quiet waters of the lagoon and in the shallow pools on the island upstream from the lagoon.

They often fed in small loose groups of two to four birds but never in the large flocks characteristic of coastal terns. This was probably because the food fishes did not travel in such large schools as do marine fishes.

While fishing, a least tern hovered from a few feet to as much as 10 feet above the water, seldom higher. If the prey was sighted the bird quickly plunged to the surface, usually breaking its fall just before reaching the water so that instead of diving beneath the surface it only partially submerged. At times instead of one complete plunge it came down in a series of alternating short dives and hoverings as if not sure of its target. The final dive often occurred from no more than a few inches above the water.

Success in feeding varied a great deal. An adult occasionally left the nest and returned in two or three minutes with a fish and repeated this performance several times in quick order. Yet birds observed feeding along the river would often dive from five to ten times with no success.

Although in many regions interior least terns frequent nearby lakes for food (Coffey), at Bell Island this was not the case. The birds

occurred in scattered numbers as far upstream as the upper end of the island, but not beyond. They were likewise not of regular occurrence in the Shawneetown area only a mile downstream.

Defense and Fear Reactions

An upflight was the immediate reaction to disturbance in the ternery. This occurred at so slight a provocation that it often took place three or four times in a space of five minutes. Palmer (1941) divides these upflights into three types: alarms, dreads, and panics. Only the first two were observed at Bell Island.

Alarms. These were the most common type of upflights at Bell Island and seemed to have the least element of fear in them. Alarms varied much in intensity from flights of only a few terns resulting from a minor disturbance such as a boat on the river, to flight of all terns most commonly caused by an approaching vulture, crow, or human.

At the approach of a river boat the flight was apparently based on curiosity rather than fear. The birds took off calmly, uttering a short kip, kip call. They then flew out over the river, occasionally following the vessel for a short distance. They were never seen to feed in these flights.

At the approach of a crow or vulture the flight was more sudden, and usually all members of the colony participated. After all terns were in the air they gathered in a flock and flew above the intruder, attacking in groups of two or three in a well organized and continuous barrage. They never seemed to strike the bird and always gave up the chase near the edge of the ternery or slightly beyond. In these attacks the terns kept up a constant chattering.

Whereas the attack on a crow or vulture seemed to contain mixed elements of "excitement of the chase" and anger, the attack on a human was one of total and extreme anger in which the birds hovered over the victim uttering a sharp kek-kek-kek. This call-note ceased in the dive and was replaced by a harsh zheer as the bird swooped near. The terns never struck but often defecated on the observer in these attacks.

Defense reactions became more intense after the young hatched. After July 8 when the greatest drop occurred in the population, social attacks diminished and all intruders were ignored except when they were close to a chick.

Dreads. The sudden advent of danger, such as the abrupt appearance of the observer from the blind, precipitated these flights. The departure was hurried and silent toward the water. The birds never rose high in the air until they reached the water where they gathered in a flock and returned to defend the ternery.

All defense reactions ceased at the outer extremities of the ternery. No alarm resulted from other birds or humans along the beach or on the point, until the young had left the nest and were then present in these areas.

Reaction to Injured Terns

Only one observation was made of the reaction of terns to an injured fellow. A female tern was unable to fly and fluttered along the beach. Approximately 10 other terns flew over her. They were too far away for the observer to hear their calls. They soon began to dive at her in much the same manner that they had employed with the crows and vultures. Later the writer found the bird dead. The exact cause of death was not noticeable in an autopsy. Palmer (1941) states that in common terns

if the injured bird is enfeebled and shows no blood in the plumage, the other terns merely fly over it. If blood is visible, they attack. The least tern was attacked even though there was no blood visible on a later examination.

DEPARTURE FROM THE TERNERY

Least terns whose nests have been destroyed do not remain in the ternery. After the great loss of young between July 5 and 8 at Bell Island there was a corresponding reduction in the number of adults. Before this disaster a vulture flying over the ternery usually attracted between 55 and 65 birds to the attack. Later the same bird was pursued by only 3 to 15 birds. Other terns were present in the area but they did not join in the attack, probably because they had either lost or had never had social ties with the Bell Island ternery. The number of terns in the ternery decreased to two adults on July 27, and these were present for only a few minutes during a three-hour period. No other terns were seen in the entire area that day.

Departure from the ternery varies widely according to the season and the area under observation. Stiles (1939) stated that least terns in Iowa had not all departed from the ternery until early September. Water levels and resultant late nesting were the apparent cause of this.

POST-BREEDING ACTIVITIES

When the young are able to fly for sustained periods they desert the ternery and in company with the adults wander along the rivers and lakes for several weeks before migration. (For the extent of these wanderings see the section on distribution.) In these nomadic movements they can often be found associating with other terns, sandpipers, and plovers. On August 30, 1953, the writer saw a flock of about 20 birds, both adults and young, at Bell Island. These were obviously not birds raised there since about half of them were young-of-the-year. Similar flocks were noted at the Carbondale Reservoir, a shallow lake in Jackson County, Illinois, from late August to mid-September. Though all these young were able to fly they were not adept at fishing. They followed the adults about and were fed occasionally by them. The feeding always took place on the ground. Rarely did they dive for fish and then awkwardly and without success. This feeding of the young by the adults indicates that the birds may migrate in family groups at least during the early part of fall. Whether members of a colony remain together is not known.

SUMMARY AND CONCLUSIONS

This study of the interior least tern (*Sterna albifrons athalassos* Burleigh and Lowery) was divided into three parts: (1) An actual field study of a colony of these birds at Bell Island in the Ohio River made during the summer of 1953 from June to September; (2) an analysis of all available information in published literature; and (3) correspondence with ornithologists throughout the range of the subspecies.

The interior least tern ranges in summer from Baton Rouge, Louisiana, north and west on the Mississippi River system to Indiana, western Iowa, South Dakota, Wyoming, Kansas, and Oklahoma. Formerly it occurred in north central and eastern Iowa, and in eastern Montana.

Migration begins on the Gulf of Mexico coast in April. Terns, following the river, reach Mississippi and Tennessee in late April and early May, and by late May have appeared in Iowa and in the plains states. Some early records in Nebraska and Oklahoma indicate that cross-country migration occurs.

After the nesting season least terns wander up the Ohio River as far as the Falls of the Ohio at Louisville, Kentucky, with single records from Ohio and Wisconsin.

Fall migration begins in late August and early September. Few terns linger past the second week in September in the north. October records are occasional from the lower Mississippi River. Some winter in Louisiana and along the coast.

The presence of sandbars, the existence of favorable water levels, and the availibility of food are the three most important factors in the occurrence of the least tern on the rivers.

Sandbars are formed when a stream reaches grade level, at the mouths of tributary streams and in the plains area when summer droughts occur. Isolation, height of the bar above water and duration of the bar are important.

From the information available it appears that the beginning of the breeding season is definitely governed by the spring flood conditions. Flood waters usually subside in June so that nesting begins soon after. Severe floods may prevent nesting or delay it until July and August. It is possible that over the years the regular delay in nesting has caused a physiological adaptation so that nesting would be late regardless of flood.

Conditions favorable to sandbar formation also favor shallow waters where an abundance of minnows is available to the terns. Interior least terns probably feed almost entirely on minnows. At Bell Island the dominant food fish was probably the river shiner (Notropis blennius).

Sand surface temperatures are considerably higher than air temperatures. At Bell Island they commonly exceeded 100° F. Such temperatures require that the eggs be shielded from the sun since optimum incubation temperature for most birds is about 93°. The young suffered from these excessive temperatures, but no deaths were directly attributable to heat.

The breeding cycles of nearly all terns in a colony are synchronized by flood conditions. By the time bars are exposed practically all terns are in the breeding area and thus commence breeding activities at the same time.

Courtship of the least tern is similar to that described for other terns except that the fish flight is not so prominent. It consists of

the aerial glide, posturing, parade, copulation, and incipient nest-building. Courtship rarely takes place in the ternery except for the last phase.

The size of interior least tern colonies ranges from a few to as many as 30 pairs. Small colonies are the rule on the smaller streams in the plains area and in the north; larger colonies are found on the Mississippi River. The Bell Island ternery of approximately 30 pairs is the largest reported.

Interior least terns usually do not nest in compact groups. At Bell Island the nest area was about 120 acres, the density 0.7 nests per acre. The birds usually nest some distance from the water on the highest part of the bar.

Because of the relatively great distance between nests territorial disputes seldom occur in the colonies.

Nest-building is initiated by scrape-making. The nest is only a shallow depression in the sand or gravel. Scrapes are used not only for the eggs and newly hatched chicks but are constructed for temporary brooding of chicks which leave the nest.

The eggs average 31.2 X 23.8 mm. and are buff or olive buff speckled with brown and gray. The size of the clutch varies in general from two eggs in the south to three in the north. One to four eggs are occasionally found. At Bell Island about 80 per cent of the clutches contained three eggs, 20 per cent two. The eggs are probably laid on successive days. This belief is supported by the fact that at Bell Island the young always hatched on successive days. Apparent infertility of eggs at the island was about 3.6 per cent.

Although there has been disagreement concerning the length of the

incubation period, it is now considered to be about 20 days. This was in agreement with probable beginning of nesting at Bell Island (soon after the flood waters subsided) and the first hatching.

Participation in incubation by the adults varied in different pairs. In some it was equal, in others the female performed almost all incubation and was fed by the male or relieved by him for short periods.

Hatching at Bell Island began June 30 and the greater part of it occurred in the week following. The young are covered with yellow or buff-spotted down, and weigh about 5 grams. They are able to walk on the second day.

Post-natal molt begins about the end of the first week. Weight at this time is about 15 grams. At the age of two weeks the juvenal plumage is nearly complete except for the tail. The color is now buff and gray shading to slate on the wings.

The chick flies at about 20 days. At this period the plumage is not much changed from the two-week-old bird.

With the first hatched young the parents instinctively switch from incubation to brooding and feeding. Brooding is primarily by the female, the male relieving her for short intervals. Feeding is carried out by both birds. Both activities are most prevalent during the heat of the day. Early in the morning and late in the evening the chicks are active and refuse brooding and feeding. Feeding is direct and only very small fish are given to the young at first. All receive about equal attention, since a chick once fed is usually satisfied for several feeding visits afterwards.

Mortality is high among least terns in and prior to the pre-flying stage. At Bell Island this was attributed to infertility of the eggs,

desertion of the eggs resulting from the parents caring for the first born young which usually left the nest on the second day, parental neglect of the young, exposure to the sun, and predation. In some regions, especially the plains areas, flash floods take a heavy toll.

At Bell Island the terns fished in the shallow waters near the bar. The birds seldom hovered over ten feet above the water in search of prey. The dive was either continuous or in a series of short plunges. They never completely submerged in catching fish.

Least terns usually nest apart from other species; however, they have been reported nesting with piping plovers in Nebraska and snowy plovers in Oklahoma. At Bell Island no other species nested on the bar.

Bank swallows, killdeer, and kingbirds plus probable predators such as the crow, turkey vulture, black vulture, and black-crowned night heron were frequent visitors near or in the Bell Island ternery. Although classed as probable predators, the last four species were never observed preying on terns.

Interior least terns are of little economic importance to man. However, they are shot as a nuisance at a fish hatchery near North Platte, Nebraska.

Defense and fear reactions could be classified as alarms or dreads (Palmer, 1941). The birds attacked all crows, vultures, and humans entering the colony. They were also put to flight by boats on the river. Reaction to an injured tern was to attack it in a manner similar to the attack on a predator.

Departure from the ternery is gradual. Terns whose nests were destroyed left the colony promptly. At Bell Island the colony was all but

deserted by the last week in July.

After leaving the ternery interior least terns wander along the rivers and lakes associating with other shore birds. The young are fed by the adults during these movements. This indicates that family groups may migrate together.

LITERATURE CITED

Agersborg, G. S.
1885 The birds of southeastern South Dakota. Auk, 2:276-279.

Anonymous
1953 Twenty-five year summary of bird migration in Nebraska, part 8, gulls to cuckoos. Nebr. Bird Rev., 21:15-18.

Austin, O. L.
1934 The status of Cape Cod terns in 1934. Bird-Banding, 5:155-171.

1938 Some results from adult tern trapping in the Cape Cod colonies. Bird-Banding, 9:12-25.

1947 A study of the mating of the common tern (Sterna h. hirundo). Bird-Banding, 18:1-16.

1949 Site tenacity, a behavior trait of the common tern (Sterna hirundo Linn.). Bird-Banding, 20:1-40.

Austin, O. L., Jr.
1929 Contributions to the knowledge of the Cape Cod Sterninae. Bull. Northeastern Bird-Banding Assn., 5:123-140.

Bartsch, P.
1922 Some tern notes. Auk, 39:101.

Benckeser, H. R.
1948 Notes from Brule. Nebr. Bird Rev., 16:94-96.

Bennitt, R.
1932 Check-list of the birds of Missouri. U. of Missouri Studies, 7:1-81.

Bent, A. C.
1921 Life histories of North American gulls and terns. U.S. Nat. Mus. Bull., 113:1-340.

Beyer, G. E.
1907 List of the birds of Louisiana, part iii. Auk, 19:314-321.

Burleigh, T. D. and G. Lowery Jr.
1942 An inland race of Sterna albifrons. Occ. Papers Mus. Zool. (La. St. Univ.), 10:171-177.

Butler, A. W.
1898 The birds of Indiana. Report of State Geologist, 1897:515-1187. Indianapolis.

Campbell, L. W.
1934 Least tern taken near Toledo, Ohio. Auk, 52:87.

Collinge, W. E.
1929 An investigation of the food of terns at Blakeney Point, Norfolk. Trans. Norfolk Norwich Nat. Soc., 12:35-52.

Coues, E.
1874 Birds of the northwest. Dept. Interior, U.S.G.S. Territ. Miscel. Pub., 3:692-696.

Dumont, P. A.
1933 A revised list of the birds of Iowa. Univ. Iowa Studies Nat. Hist., 15:1-171.

Ganier, A. F.
1930 Breeding of the least tern on the Mississippi River. Wils. Bull., 42:103-107.

Haeker, F. W.
1937a The eastern least tern breeding in Thurston County. Nebr. Bird Rev., 5:9.

1937b The eastern tern breeding in Burt County. Nebr. Bird Rev., 5:110.

Haeker, F. W. and R. Moser.
1945 Check-list of the birds of Nebraska. Nebr. Bird Rev., (reprinted and revised Nov. 1945), P. 13.

Hager, J. A.
1937 Least tern studies--1935 and 1936. Bull. Mass. Aud. Soc., 21:5-8.

Heinemen, L. D.
1943 Nesting of the piping plover and least tern in Cass County. Nebr. Bird Rev., 11:

Hudson, G.
1939 Some ornithological results of a six-week collecting trip along the boundaries of Nebraska. Nebr. Bird Rev., 7:4-7.

Johnson, R. W.
1936 Bird migration at Dubuque. Iowa Bird Life, 6:8-9.

Jung, C. S.
1934 Occurrence of the least tern (Sterna a. antillarum) in Wisconsin. Auk, 52:87.

Lewis, W. E.
1930 Water birds in a dry land. Wils. Bull., 42:36-44.

Long, W. S.
1940 Check-list of Kansas birds. Trans. Kansas Acad. Science, 43:433-456.

Mabbett, G.
1890 A query in regard to the least tern. Auk, 7:410-411.

Marples, G. and A.
1934 Sea terns or sea swallows. London: Country Life Press, 1-227.

Marshall, N.
1942 Night desertion by nesting common terns. Wils. Bull., 54:25-31.

McCreary, O.
1934 The Platte River as a migration route for birds. Nebr. Bird Rev., 2:38-39.

Mearns, E. A.
1916 The Brown's least tern. Proc. Biol. Soc. Wash., 19:71.

Moser, R. A.
1940 The piping plover and least tern nesting in Omaha. Nebr. Bird Rev., 8:92-93.

1943 Additional notes on the nesting of the piping plover at Omaha. Nebr. Bird Rev., 11:48

Nice, M. M.
1931 The birds of Oklahoma. Univ. Oklahoma Publ. Biol. Surv., 3:1-224. U. of Oklahoma Press.

Nolan, V.
1952 A summary of the summer season (in the middle western prairie region). Aud. Field Notes, 6:284-285.

1953 A summary of the fall migration (in the middle western prairie region). Aud. Field Notes, 7:18-20.

Oberholser, H. C.
1938 The bird life of Louisiana. Bull. La. Dept. Conserv. with U.S. Dept. Agric. Biol. Surv., 28:298-300.

Over, W. H.
1921 Birds of South Dakota. Bull. S. Dakota Biol. and Nat. Hist. Soc., 9:48.

Palmer, R. S.
1941 A behavior study of the common tern (Sterna hirundo hirundo L.). Proc. Boston Soc. Nat. Hist., 42:1-119.

Peters, J. L.
1934 Check-list of birds of the world. Vol. II:1-401. Cambridge, Mass.: Harvard U. Press.

Pettingill, O. S., Jr.
1939 History of one hundred nests of arctic terns. Auk, 56:428-429.

1951 A guide to bird finding (east of the Mississippi). New York, Oxford U. Press. 1-659.

1953 A guide to bird finding (west of the Mississippi). New York, Oxford U. Press. 1-709.

Praeger, W. E.
1925 The birds of the Des Moines Rapids. Auk, 42:563-567.

Sprunt, A., Jr.
1948 The tern colonies of the dry Tortugas Keys. Auk, 65:1-19.

Stiles, B. F.
1939 The least tern in Iowa. Iowa Bird Life, 9:19-23.

Tomkins, I. R.
1934 Notes from Chatham County, Georgia. Auk, 46:283.

Tout, W.
1934 Water-bird concentrations due to drought. Nebr. Bird Rev., 2:66.

1947 Lincoln County birds. Pub. privately by author. pp.67-69.

Visher, S. S.
1915 A list of the birds of Clay County, southeastern South Dakota. Wils. Bull., 27:324.

Wetmore, A.
1913 Birds observed near Minco, Central Oklahoma. Wils. Bull., 30:2-10.

Witherby, H. F.
1941 The handbook of British birds. Vol. V:1-356. H. F. and G. Witherby Ltd., London.

Worth, C. B.
1940 Egg volume and incubation periods. Auk, 57:44-60.

Wycoff, R. S.
1930 untitled. Nebr. Bird Rev., 18:30-31.

Youngworth, W.
1930 Breeding of the least tern in Iowa. Wils. Bull., 42:102-103.

1931 The American egret and least tern in South Dakota. Wils. Bull., 43:309-310.

1932 Field notes from Sioux City, Iowa. Auk, 49:494.

1933 Spring migration dates from Sioux City, Iowa. Wils. Bull., 3:38.