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modifications. The weights of the glands did not give consistent results.

In the pituitary, the basophils remained about constant in size and number. A few degranulated cells were observed in the experimental animals. The chromophobes decreased in number (10%) in the experimental group, but remained constant in size. The eosinophils increased in number (10%) in the experimental group. The latter cells remained about the same size as that observed in the normal control and did not show any evidence of degranulation. Measurements of the Golgi material were also made for the three types of cells in the anterior lobe of the hypophysis.

THE RELATION OF TEMPERATURE AND SNOW COVER TO SPRING BIRD ARRIVAL

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The purpose of this study was to determine what relationship might exist between temperature and snow cover and the spring arrival of birds in the central Minnesota area. The bird arrival records of one hundred species collected by the ornithology classes at the St. Cloud State Teachers College, and the temperature and snow cover data from the Minnesota State Reformatory Weather Station, both located at St. Cloud, Minnesota, were employed to make the study.

People have long speculated over the cause or causes of the annual migratory movements of birds. Those which especially interest the present day ornithologist center in the birds' response to light, temperature, food, and sex gland development. If it were possible to keep three of the four factors mentioned above constant, with one of them variable, and have each factor in turn studied in this manner, the real solution to bird movement might be discovered here.

The records of the college over a nine year period, show rather strikingly that the bird influx coincides with the increase of temperature. Birds vary in their arrival as much as one to three weeks, depending upon the nature of the temperature and snow cover.

The temperature for the month of March, 1938, was considerably above the average; and various species of birds arrived much earlier than their average arrival time as shown by the nine year period. During the first week of April the temperature dropped from 45° to 25° Fahrenheit above zero accompanied by snow fall. Migration into this vicinity ceased. During this cold period birds were seen south of the Twin Cities along the Mississippi River below the cold belt, apparently waiting for warmer weather conditions. Then,

as the temperature returned to normal, the northern movement was again resumed. In figure 1 the curve representing the species arrival follows very closely the rise and fall of the temperature for the spring migratory season of 1938. This relation existed for each of the years that the records were kept, 1930 to 1938, and a composite curve of these arrivals, as shown in figure 2, indicates that the species arrivals follow very closely the rise in temperature.

The dates and air temperatures of the time of arrival of four of the common birds, tree sparrow, western meadow lark, purple martin, and green wing teal, are recorded in Table 1 for the years 1933–1938 inclusive. It will be noted that, while the arrival dates vary considerably for each of the birds, the air temperatures are fairly constant. If from the arrival dates the average week of arrival is calculated for each species and the temperature for this week is found, taken from figure 2, it will be noted that this temperature for the average week of arrival corresponds very closely to the actual average temperature that the species did arrive. These data would seem to indicate that specific temperatures play an important role in the migratory movements of birds.

TABLE I.—TIME AND TEMPERATURE OF ARRIVAL

Bird	1938	1937	1936	1935	1934	1933	Average Week	Temp. for Av. Week	Av. Temp. Arrival
	Week Temp.	Week Temp.	Week Temp.	Week Temp.	Week Temp.	Week Temp.			
Tree Sparrow	Feb 4 26.6	Mar 3 25.7	Mar 2 27.5	Mar 2 25.9	Mar 1 29.9	Apr 1 35.7	Mar 3	30.2	28.5
W. Meadow Lark	Mar 2 28.3	Mar 4 24.2	Mar 3 34.6	Mar 2 25.9	Mar 4 25.8	Mar 4 36.0	Mar 4	31.2	29.1
Purple Martin	Apr 2 48.3	Apr 2 42.1	Apr 2 42.9	Apr 2 42.6	Apr 1 41.0	Apr 1 35.7	Apr 2	45.3	42.1
G. Wing Teal	Mar 3 44.5	Apr 2 42.1	Apr 3 40.6	Apr 3 43.5	Apr 3 42.5	May 1 47.4	Apr 2	45.3	43.1

The number of species arrivals during the early migrating season increases directly as the air temperature rises, figure 2. During the latter part of April this number drops off sharply, to be resumed again in early May, even though the general direction of the temperature curve is upward. The records for each year show this same break in migration which probably can be explained by the food habits of the various species. The earliest arrivals are herbivores, or seed eating birds, and the second large group, arriving mainly during April, are the omnivores, or both plant and animal eating birds. Most of this group have arrived before insects hatch out in consid-

erable numbers, which seems to cause a break in the migratory wave between the omnivores and insectivores. The bulk of the insectivores do not appear until the temperature is warm enough to hatch considerable numbers of insects.

Another factor that seems to determine the time of arrival of the early species is that of snow cover. The great amount of snow in the year 1936 seemed to slow up the rate of arrivals for some time. When it was down to an average depth of from two to four inches, the number of species arriving quickly increased as shown in figure 3. This same relationship was found to exist for each of the years and especially so in the years of heavy snow fall. This snow factor is also shown in the composite curve figure 4, for the years 1930 to 1938 inclusive. In figure 3, there is a drop in species arriving from the third week of March to the first week of April though the snow continued to decrease in depth. This is probably due to a drop in temperature from an average of 34.6° to 22.1° Fahrenheit. These data seem to indicate that snow cover is an important factor in determining the number of early arrivals.

The early arrivals are hardy herbivores, crow, prairie horned lark, slate colored junco, tree sparrow, blue bird and robin, or birds that can live on seeds in the early spring. These birds seem to wait until the snow cover is reduced to four or less inches in depth which means many places are bare of snow, thus making available sources of food. Since the amount of available food for the early herbivores is largely controlled by depth of snow cover, and since the depth of spring snow cover is largely determined by air temperature, then the amount of available food for these early migrants apparently is controlled indirectly by the air temperature.

The early arrivals are winter residents of the nearby states to the south of Minnesota. The waterfowl and carnivores are chiefly winter residents of southern United States with a few species coming from Central America, and the insectivores, the last group to arrive, are chiefly winter residents from southernmost United States to central South America.

Since the depth of snow cover and the available food supply are generally dependent on the air temperature, and the data indicate that the birds arrive at approximately a certain temperature for each species, we may expect these species to arrive according to temperature rather than according to time. Table II, worked out from the temperature of the arrival dates, shows a list of common birds and the air temperature at which to expect the different species to arrive in considerable numbers. The various species then, will arrive when the weather warms to approximately the average air temperature as listed on table II. For example, the chimney swift will arrive when the average temperature reaches approximately 50° to 55° Fahrenheit though the time of month will vary considerably from year to year.

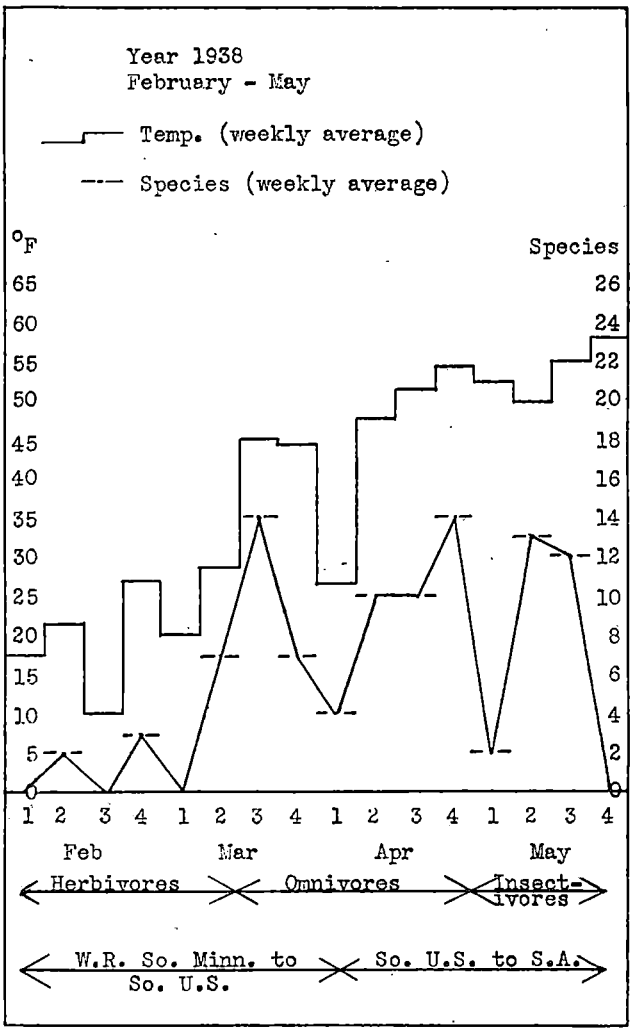

FIGURE 1

As the temperature rises, the number of species arriving increases. During a cold stormy period the number quickly drops and these species arrive when the temperature again rises to normal. The number of species arriving correlates quite closely with the temperature except for a period between the omnivores and insectivores. The early herbivores, chiefly winter residents near southern Minnesota, arrive in February and the first two weeks of March. The omnivores, chiefly winter residents of southern United States, arrive from the middle of March to the last of April. The insectivores generally arrive in May.

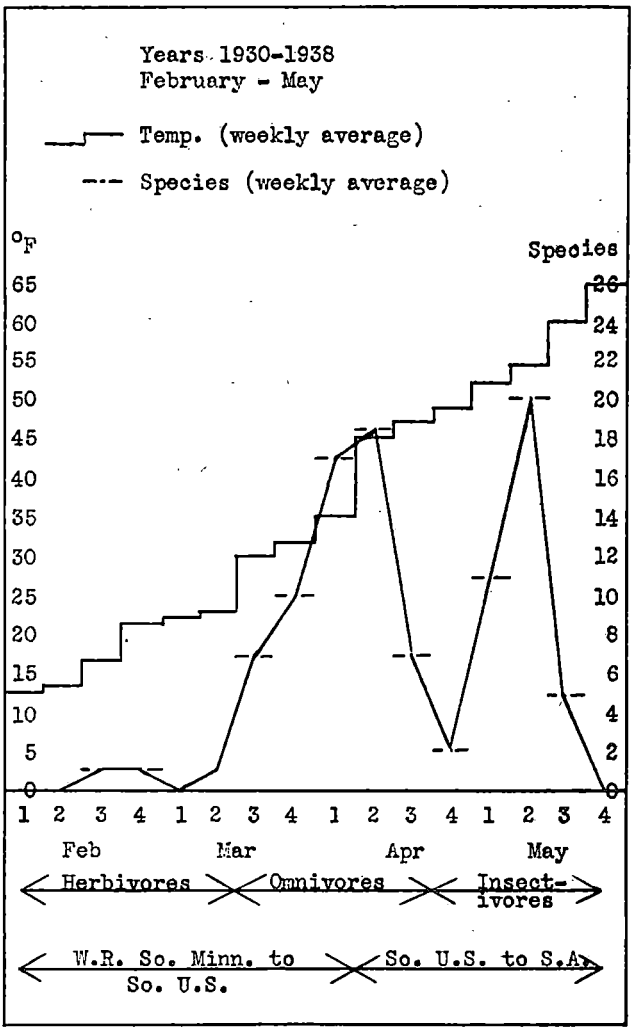
Years 1930-1938
February - May
Temp. (weekly average)
Species (weekly average)
°F
Species
65
60
55
50
45
40
35
30
25
20
15
10
5
0
26
24
22
20
18
16
14
12
10
8
6
4
2
0
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
Feb
Mar
Apr
May
Herbivores
Omnivores
Insect-ivores
W.R. So. Minn. to So. U.S.
So. U.S. to S.A.

FIGURE 2

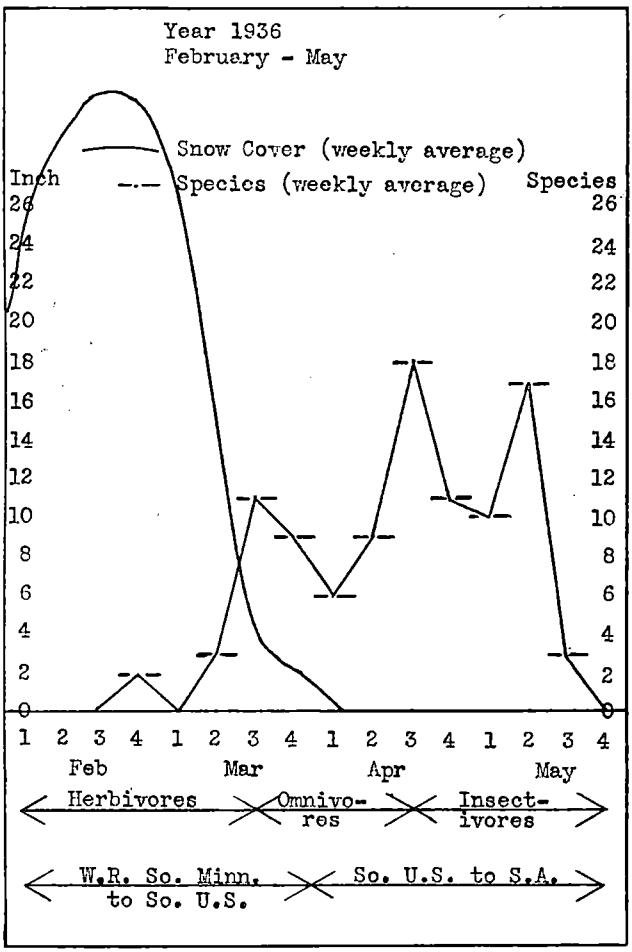

FIGURE 3

Very few species arrive in considerable numbers until the average snow level is from four to six inches in depth. This exposes considerable quantities of seed for the herbivores. The bulk of the omnivores arrive when most of the snow and ice have melted from the field and streams.

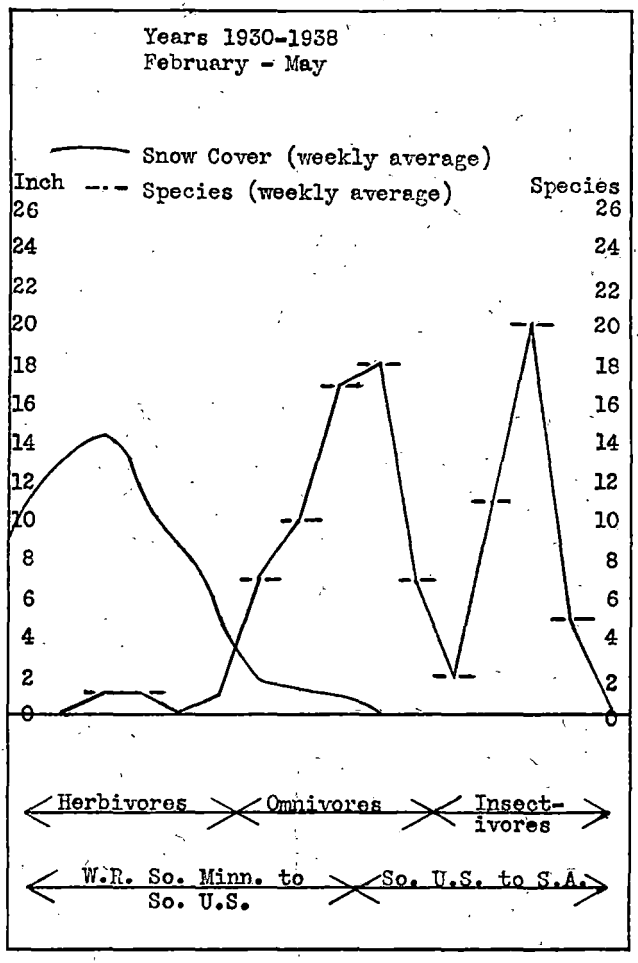
Years 1930-1938
February - May
Snow Cover (weekly average)
Species (weekly average)
Inch
Species
26
24
22
20
18
16
14
12
10
8
6
4
2
0
Herbivores
Omnivores
Insect-ivores
W.R. So. Minn. to So. U.S.
So. U.S. to S.A.

FIGURE 4

TABLE II.—TEMPERATURE OF ARRIVAL

°F		
		Wood Peewee
		R T Hummingbird
		Cres Flycatcher
	55	
		E Kingbird
		Palm Warbler
		Baltimore Oriole
		House Wren
		Brown Thrasher
	50	
		Swamp Sparrow
		Am Bittern
		Y B Sapsucker
	45	
		G W Teal
		P Martin
		D C Cormorant
		Pied Bill Grebe
		Kingfisher
		Pintail
	40	
		Coot
		Sparrow Hawk
		Scaup
		Loon
	35	
		Robin
		Purple Finch
	30	
		Redstart
		Least Flycatcher
		Yellow Warbler
		B and W Warbler
		Pine Warbler
		Chimney Swift
		Catbird
		R W Swallow
		Bank Swallow
		W T Sparrow
		Cowbird
		Fox Sparrow
		Chipping Sparrow
		Vesper Sparrow
		Bronze Grackle
		Great Blue Heron
		Red W Blackbird
		Marsh Hawk
		Song Sparrow
		Mallard
		Broad Wing Hawk
		Meadow Lark
		Slate C Junco
		Bluebird
		Am Golden Eye
		Tree Sparrow
	25	
	20	
		P Horned Lark
		Crow

If from these data we may assume that temperature is one of the controlling factors in migration, it would give rise to several questions which might well be considered.

1. Is there any relationship between temperature and sex gland enlargement; in other words is sex gland enlargement caused by a rise in air temperature?
2. Do birds leave their wintering areas when the air reaches approximately a certain temperature for each species? If the air temperature of the wintering is unusually high in the early spring, do birds begin their migration earlier?
3. If so do they migrate slowly on their way north, keeping within temperature limits for each of the species?
4. Do birds migrate as far south during a mild winter as they do during an average winter?

Northern states ornithologists would be greatly interested in any studies pertaining to air temperatures at the time that the bulk of a given species leave their winter home and when they arrive at the various banding stations en route to the northern states.

Summary

1. Air temperature seems to be one of the determining factors in bird migration.

2. The air temperature ranges within very narrow limits at the time of arrival of any given species of birds for any year in the St. Cloud area.

3. The species seem to arrive according to temperature rather than according to time.

4. Available food supply and snow cover, generally dependent on temperature are important factors in species arrival.

NOTES ON MINNESOTA TICKS *

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The classic studies of Smith and Kilbourne on the rôle of ticks in the transmission of the Texas fever of cattle led to the study of these overgrown mites in all parts of the world and each year sees additions to our knowledge of the species, their ecology, distribution and their medical and veterinary importance. There is ample opportunity for local workers to contribute important data regarding the ticks found in Minnesota and it is with the idea of stimulating interest in the group that these notes are presented.

Ticks belong to the superfamily *Ixodoidea*. Like mites in general, they have the head, thorax, and abdomen fused to form a sac-like body. The so-called "head", technically the *capitulum,* is really the fused mouth parts. In the family Ixodidae, the group to which most of our Minnesota species belong, this capitulum projects from the anterior end of the body but in the Argasidae it is ventral in position in the adult tick. The most characteristic feature of ticks is that the *hypostome,* or central portion of the mouth parts, is file-like, due to the presence of recurved teeth which served to attach the tick firmly to its host. Newly hatched larvae, or "seed ticks" are six-legged, while nymphs and adults are eight-legged.

We shall not enter into a discussion of tick morphology at this time, but in figures 2 and 3 the structures most used in taxonomic work are labeled.

Minnesotans in general are acquainted with only a single species, popularly called a "wood tick" which is so frequently encountered throughout spring and early summer. It is *Dermacentor variabilis* (figs. 1, 2, 3) the American dog-tick, which is not only found in most parts of the state but is widely distributed over the eastern and southeastern United States. The adult tick, emerging in Minnesota in early spring, attaches to dogs, wolves, cattle, horses and various large mammals, including man. The larvae, or so-called "seed ticks",

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