The foot is capable of great extension as may be observed if living shells are placed in a glass bowl or aquarium. Cilia in the bronchial siphon, and along the inner and outer gills and mantle, induce currents which bring diatoms and other minute organisms contained in the water into contact with the libial palpi, whence they pass into the stomach to be in part elaborated for the preservation and growth of the individual and the propagation of its kind, and in part rejected through the excurrent or cloacal siphon.

Unlike the *Unionidae* in which each individual is dioecius, that is, either a male or a female, as is the case also with our native oyster (*O. virginica*, Gmelin), though not, strange to say, with its European relative (*O. edulis*, Linn.), *S. sulcatum*, like all other species of the *Sphaeriidae*, is monoecious, or produces both sperm and ova within the same shell. However, it is not harmaphroditic in the way that many, if not all, pond and other snails are hermaphroditic. In their case, while each animal is perfectly bisexual, the conjunction of two individuals is requisite for fertilization. In the *Sphaeriidae*, on the other hand, the process of fertilization is similar to that which takes place within the closed keel of the pea blossom and other legumes. Cross fertilization is impossible naturally, and could not be induced artificially were another Mendel to arise. The reproductive organs are located behind the stomach, and consist of racemose glands, the anterior of which produces sperm, and the posterior ova. A common genital duct leads in the cloacal chambers of the inner gills, where the young reach before birth, in the case of this species, a length of seven or eight millimeters, or nearly half that of the father-mother.[5] If living shells are left for a day or two in water that is warmer or colder than that of their usual habitat, they will, ordinarily, be found to have produced a large number of nepionic young. These should be separately boxed and labelled with the name of the parent and will be found very useful when the collector is trying to identify shells which are no larger when aged than some Sphaeria are at birth.

(To be continued)

[5]The reproduction and growth of S. sulcatum are treated at length by Ralph J. Gilmour in The Nautilus, Vol. 31 (1917), pp. 16-28.

Note.—It is my intention to place in the Museum of the Geological and Natural History Survey at Ottawa specimens of the forms and varieties of S. sulcatum, and of the species mentioned in the continuation of this paper, of which I possess duplicates.

FIELD STUDY OF LIFE-HISTORIES OF CANADIAN MAMMALS.[1]

BY RUDOLPH MARTIN ANDERSON, BIOLOGICAL DIVISION, GEOLOGICAL SURVEY, OTTAWA.

A recent and timely publication of the United States Department of Agriculture[2] calls attention to the gaps in our knowledge of the habits of many of the commoner species of mammals. The study of birds has been developed so extensively in a popular way in recent years through the Audubon Society movement, local bird clubs, and nature studies in the public schools, as well as technically by the scientific ornithologists, that the objects and methods of bird study have become fairly well known throughout the country, and the economic importance and aesthetic and sentimental value of bird life are becoming matters of common knowledge.

The study of mammals, though not less important in many ways, has not been developed so broadly or systematically. The study of the comparative anatomy and physiology of the major mammalian groups, through their closer relation to the human subject, has received close attention, but the relations of species to one another and to their environment, and their life-histories, are undoubtedly less well known than the like relations of birds. It is true that the horse, cow, sheep, pig, and a few other mammals have been domesticated, but few attempts have been made to domesticate other species except in a sporadic way. A rather extensive but scattered literature has been developed concerning the deer, elk, moose, bison, antelope, and other large game animals, which are of interest to the sportsman. Unfortunately, this in many cases consists principally of the lore of hunting field and methods of capture, and what may be termed their more intimate history has been neglected until many of the species have been exterminated over most of their former ranges, and it is forever too late to obtain complete data in regard to these animals' relations to their primitive condition. Where efforts have been made, often too late, to conserve a remnant of these animals, to replenish the game of the sportsman, add to the food supply, or for other practical or sentimental reasons, it is found that there is a lamentable lack

[1]Published by permission of the Geological Survey, Ottawa, Canada.

[2]Suggestions for Field Studies of Mammalian Life-Histories. By Walter P. Taylor, Assistant Biologist. September, 1919. U.S. Department of Agriculture. Department Circular 59. Contribution from the Bureau of Biological Survey, E. W. Nelson, Chief; pp. 1-8.

of knowledge even of an elementary kind regarding their habits.

Intimate knowledge of the furbearers was left largely to the trapper, whose interest usually did not extend beyond the means of outwitting the animal during the trapping season, putting its pelt on the stretcher or drying-board, and increasing his own personal fur-return for the time being. As the furbearers have become reduced in numbers, and the prices of fur have increased, the importance of the fur industry to the country is becoming recognized; measures of conservation are being proposed, and fur-farms are being started, the practical success of which depends largely upon the application of a knowledge of life-histories or habits of the animals which are to be reared.

Many species of animals which have no direct economic value as food or for their fur, or skins, are nevertheless often of enormous indirect importance, and must be recognized as beneficial, or means taken to combat them as detrimental to the interests of man. Rats, mice, ground squirrels, etc., have been recognized as carriers of trichinae and the germs of bubonic plague, anthrax, and other diseases. Ground squirrels, prairie dogs, pouched gophers, and other rodents have caused such extensive damage to grain-fields, running into millions of dollars annually in some parts of the country, as to make necessary concerted action by the government and by associations of individual farmers. Rabbits, hares, voles (field-mice), and the like frequently cause great damage to fruit trees and young forest trees. Coyotes, wolves, and mountain lions take a large toll of the sheep, cattle, and horse-raising industries, and thousands of dollars had been expended in indiscriminate bounties without commensurate results until systematic study of these carnivorous pests pointed a way for their practical elimination in many districts.

The ravages of "The house rat, the most destructive animal in the world," are given by Lantz (Yearbook of the United States Department of Agriculture, 1917), from studies made by the Biological Survey in 1908, as amounting to actual losses in produce and other property in one year in the two cities of Washington and Baltimore, of $400,000 and $700,000 respectively, the sums being nearly in ratio to the population. In the same report he quotes a recent statement of the Women's Municipal League of Boston to the effect that losses from the rats in that city amounted to $1,350,000 annually. Losses in Pittsburg, Pa., have been estimated at over $1,000,000 a year, and no doubt the present values of produce would greatly increase these estimates.

While the study of the living animal is of as great interest and attractiveness to the naturalist as any other branch of natural history and has consequently an aesthetic and sentimental value, it can be shown to have a very practical value also. As Professor Herbert Osborn says: "Not a single farm product but is affected directly or indirectly by some animal activity."

Dr. Taylor, in his recent paper, states that the leading museums have been acquiring exhibits and studying material representatives of different groups of birds and mammals, until at present the American collections are in many respects unsurpassed by those of any other country in the world, and that the relative completeness of research collections permits increased attention to be paid to the study of life-histories.

It is, of course, well recognized that species closely resembling each other often have quite different habits, and to avoid misapprehension and confusion of records we must have a certain amount of systematic taxonomic study before detailed investigations can be made along other lines. Valuable observations may be made without drawing the lines of differentiation too finely, but in general, we must learn the names of our animals before we can write about them. In other words, we must have pegs on which to hang our observations, if they are to be of value.

Unfortunately, we must admit that there is not in Canada today any collection of mammals approaching in completeness, even in Canadian species, several collections in the United States, among which may be mentioned the Biological Survey and the United States National Museum of Washington, the American Museum of Natural History of New York, the Museum of Comparative Zoology of Cambridge, and possibly two or three others. Many American zoologists have worked in Canada for the enrichment of American museums, and Canadian naturalists have done intensive work in many districts, but many regions of Canada have even yet been little worked in the field of mammalogy.

The development of a national collection of the mammals of Canada, as well as of other forms of animal life, should be of interest to all Canadians. Such a collection is useful as a place of reference for students from all parts of the country, and a permanent repository for specimens of many species which may ultimately become extinct. In addition to the national collection, represented by the Victoria Memorial Museum, under the Geological Survey, of the Department of Mines, each province should have a representative collection of the mammals and other vertebrates found within its borders. The private collector has a field of his own for investigation and experiment which should be en-

couraged, for he often has opportunities, resources, and freedom to carry on important investigations along side paths of knowledge which the government investigator or professional naturalist is not able to follow at his own inclination. The universities, colleges, and other schools, scientific surveys and commissions, local museums and associations for the protection of fish and game, all have an opportunity to do good work for the country in this field.

The value of detailed knowledge in fields which have previously appeared seemingly trivial, has been illustrated many times during the late war. As an example of this, the pest of rats became exceedingly serious at the Bush Terminal of the port of New York, the principal shipping point of the immense amount of stores required for the American or other expeditionary forces of the Allies. The use of poison was impracticable around such great quantities of food stuffs, but by detailing field biologists to the Sanitary Corps and directing their field experience to the problem of exterminating rats, within a few months more than 50,000 rodent allies of the enemy were accounted for, and it is estimated that several million dollars worth of commissary and quartermaster stores were saved at a critical time.

The secretive and nocturnal habits of some species of small mammals are responsible for so little being known of them. They are correspondingly more difficult to photograph than the birds. For this reason field photographs of mammals—their nests, runways, tracks, and general habitat, are particularly desirable. Although the mammals as a rule are more shy than the birds, and are less often seen; the larger animals on account of constant pursuit by man for generations as objects of sport and of food, and the smaller ones from fear of swooping birds of prey, the presence of the mammal in a certain region may be detected where the flying bird leaves no trace. The pads of little paws on dusty roads or the muddy brinks of pools or streams, or the delicate tracery of tracks on the newly fallen snow, leave a record, which though evanescent, may be read and interpreted by the initiated, and lends interest to walks in the great out-doors.

In a field like this no one can cover every detail, and the notes of many persons are needed for working out complete life-histories of any species, even the commonest. A young observer may find out something that was not known before and, in classic phrase, "add something to the sum total of human knowledge." As a suggestion to aspiring naturalists who are at a loss to know what to do or how to begin, we can not do better than quote from Dr. Taylor's paper cited above:

DATA THAT ARE IMPORTANT.

MEANS OF DETECTING PRESENCE OF PARTICULAR SPECIES.

"Tracks, distances between footfalls; differences in tracks with different speeds or movements of animal.

Feces—abundance, shape, size, color, composition, place of deposit.

Claw marks on trees, logs, or ground.

Tooth marks on wood or bone.

Wallows, dust baths, beds, forms, nests, shelters, runways, holes, trails, cropped or harvested vegetation.

HABITAT RELATIONS.

Relation of soil, rocks, water, air, climate to habits and distribution.

Effects of unusual climatic conditions, as storms, floods, and forest fires; degree and rapidity of recovery from disaster.

Relation of animal populations to climatic cycles.

INTERRELATIONSHIPS OF SPECIES.

Friends.

Enemies—times of activity; enemies in youth, middle age, old age.

Prey—modes of capture.

Parasitic habits of species with reference to each other.

Parasites, internal and external.

Bacteria and disease germs (carriage and transmission of disease to stock or to mankind; species as victims; decimation of animal populations; periodicity of contagious diseases in animals; degree and rapidity of recovery).

Adaptations of animals to each other or to plants.

Competition between species, particularly between those closely related.

TIMES OF ACTIVITY.

Hours of beginning and cessation of daily activity.

Unusual activity, as of diurnal species at night or of the nocturnal by day.

MIGRATION.

Local or general movements before and after breeding.

Dates of appearance and disappearance (especially of bats).

Extent and direction of movements, local and general.

Causes of migration—food supply, climatic, physiological.

Unusual migratory movements, as the spasmodic irruptions of lemmings, with causes therefor.

HIBERNATION AND ESTIVATION.

Date of entering upon and emerging from hibernation.

Causes of hibernation and estivation—the relation of climate, soil, physiology, and food supply.

Condition of animal before, during, and after hibernation.

Details as to completeness or incompleteness of torpidity.

Place of hibernation or estivation.

Habits associated with hibernation and estivation.

MOVEMENT.

Modes of running, jumping, climbing, digging, swimming, flying.

Gait; speed; endurance.

Other activities.

VOICE AND OTHER MEANS OF INTERCOMMUNICATION

Calls in general; courting; alarm; challenge; warning calls.

Descriptions of barking, baying, screaming, howling, squeaking, squealing, singing, roaring, bugling.

Warning attitudes; flash signals.

Emission of glandular secretions.

Odor posts.

Touch.

Other means of intercommunication.

Organization of communities—leaders, sentries, rank and file.

HABITS ASSOCIATED WITH FEEDING AND DRINKING.

List of foods eaten.

Food at different seasons.

Physical characteristics and habits associated with food getting.

Conveyance and storage of food; hay making.

Dependence on water; times and manner of drinking; other associated habits.

INDIVIDUAL CHARACTERISTICS.

General disposition and temperament; intelligence; attitudes; strength; vitality; tenacity of life; courage; esthetic sense; eating of young by parents; cannibalism in general; degree of sociability; playfulness; length of life.

Sanitation, cleanly or filthy habits.

Reactions to sound, light, odor, taste, touch.

Relation of physical characteristics to sense reactions.

RELATION OF CHARACTERISTICS AND HABITS TO EXISTENCE AND SURVIVAL.

Movements.

Attitudes.

Instincts.

Intelligence.

Coloration—concealing, disruptive, directive, warning, mimicking.

BREEDING HABITS.

Courting antics.

Relations of the sexes in general; polygamy (manner of acquisition of harem by male, mode of protection of harem, bachelor males); polyandry; promiscuity; monogamy.

Dates of heat and copulation; associated habits.

Length of period of gestation.

Date of birth of young.

Number of young.

Family life; relation of father to family; care of young—feeding; mode of carrying; how long cared for by parents; precocious or backward; length of time in nest; behavior.

Behavior of adults in postbreeding season; in winter.

Hybridization between related species.

NESTS, SHELTERS, AND OTHER PLACES OF RESORT.

Natural resorts at different seasons.

Shelter chambers in general.

Lairs; dens; forms; beds.

Nests—plan, elevation, accurate measurements; storage chambers; breeding chambers; chambers for deposit of excrement or for other purposes.

Nests for different purposes; unoccupied nests.

Approaches to nests—trails, burrows, tunnels, or runways; protection of nests through the closing of burrows during the daytime or in other ways.

Habits associated with nest approach.

Extent of home range.

MISCELLANEOUS.

Are any mammals strictly crepuscular?

Periodic phenomena of any kind of mammals, aside from migration and hibernation.

Habits as affected by the seasons of the year.

Effect of long days, very dark days, full moon, dark of the moon, on activity.

Use of glands of various sorts, as hip glands of meadow mice, metatarsal glands of deer, musk glands, anal glands.

Weights and dimensions of bats; precise hour of appearance in the evening and disappearance in the morning; numbers and habits as observed in caves; relative numbers of the sexes; methods of hanging; condition of females with reference to pregnancy.

PRESENT AND FORMER STATUS.

Present and former numbers of valuable species, as fur-bearing and game animals, and of pests or those otherwise important; causes of increase or decrease.

Estimates and counts of numbers of animals per unit of area.

Fluctuations in numbers from year to year, and causes.

Plagues, due to unusual increase or destructiveness of species; origin, course, and virulence; natural checks and methods of control.

WILD LIFE AND THE COMMUNITY.

Local names; local ideas concerning wild life.

Sentiment regarding game laws and legislation.

Trapping and hunting methods in local use; prices received for pelts or animals sold.

Relation of mammals to the public health; to agriculture.

Possible undeveloped resources in mammals, as of flesh for food, fur or hides for clothing, or other useful animal products for various purposes.

Possibilities of utilization, through domestication or semidomestication, of beneficial species."

No one individual can hope to acquire full information on all the items listed, but any naturalist who knows a species at all can put down something, and apparently trivial things often turn out to be really important when considered in their relation to other factors. "These relative lines of inquiry include problems in scientific agriculture, geographical distribution, phenology, migration, ecology, physiology, medical zoology, behavior, game protection and the conservation of natural resources, morphology, heredity, organic evolution, and economic zoology."

The Division of Biology (Mammalogy), The Geological Survey, Ottawa, Canada, is interested in building up a collection, and in gathering of life-histories and other data in regard to the mammals of Canada, and correspondence is solicited from any person or institution working along these lines, and advice or suggestions will be gladly given as opportunity is offered.

BIRDS IN RELATION TO SUNFLOWER GROWING IN MANITOBA.

BY NORMAN CRIDDLE, TREESBANK, MANITOBA.

There are several indigenous species of sunflower in Manitoba some of them such as *Helianthus maximiliani* being weeds of importance while others merely add to the attractiveness of the landscape, without being otherwise of interest to mankind. All, however, have their values in the economy of nature and for ages past have proved a valuable source of food supply for certain native birds, as well as for several rodents While animals thus take heavy toll of the sunflower seeds, they also assist materially in the spread of the species and it seems at least possible that these unusually large seeds have been evolved for just such an end. In other words, the plants offer an especially attractive food, in return for which the animals carry a certain indefinite percentage of the seeds far beyond the range that they would otherwise fall—an unconscious form of reciprocity very commonly met with in the realms of nature.

Under the ordinary course of events, the conditions depicted above might have continued almost indefinitely, but, as frequently happens, man has intervened. Sunflowers have become of economic importance from the human standpoint, the larger ones for their seeds and the smaller kinds for fodder purposes; this apart from the fact that many are grown in gardens as ornamental plants We have, therefore, to view the relations of birds to sunflowers in another light presumably, again placing the economic importance before the aesthetic. This I have endeavored to do in the following sketch. My observations are drawn largely from notes made in a garden and refer especially to a bushy type of sunflower originated by my brother Stuart. It seems well to mention also, that the garden is surrounded by shrubs and young spruce trees, planted to shelter the more tender plants therein.

At Treesbank, Man., sunflowers are usually above ground by the middle of May and it is at this time that the first injury is done to them by birds which eat the cotyledons. In doing this the birds often follow the rows to the end and practically destroy every plant. The House Sparrow having a bad name, at once got the blame for this injury and we accordingly set a watch who was prepared to shoot the none too popular bird. But suspicion may be misdirected as it proved to be in this case. There was the thief at work, pulling and eating the plants, and it proved to be no other than the White-throated Sparrow, one of the most popular of all the feathered tribe No wonder the gun was lowered or that the watcher, who happened to be my brother Evelyn, should return to the house disgusted at his discovery. Later we found that the White-throat made a practice of sunflower eating and that it continued from the time of its arrival in early May until about the first of June when the nesting period commenced. Occasionally other sparrows, such as the White-crowned or Harris' Sparrow would pull up a few plants, but they were only casual depredators whereas the White-throat went in search of the plants daily. Naturally such injury would not take place in the open country though it is possible that Longspurs or other birds might prove equally troublesome under field conditions.

The injury to the newly sprouted sunflowers is over early in June and from that time no further