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OUTLINES FOR STUDIES OF MAMMALIAN LIFE HISTORIES¹

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INTRODUCTION

Few lines of inquiry possess greater interest or importance than those that deal with the activities of the wild animal in its natural environment. Such studies also have a very practical value. The resulting data are often essential to the solution of problems in the prevention and control of animal-borne diseases, in the conservation of natural resources, and in the elimination of waste and the stimulation of production in the several branches of agriculture, including general farming, horticulture, grazing, and forestry. "Not a single farm product but is affected directly or indirectly by some animal activity," says Osborn (11, p. 112).²

Life-history data are essential also to a proper understanding of the structure and classification of the mammal; they provide the student of ancient life with materials for painting a truer and more complete picture of the past; they are prerequisite to a determination of the factors controlling distribution; and they are of very practical importance in problems of acclimatization and domestication. The improvement of agriculture depends to a large extent on a better and more scientific understanding of the relation of plants and animals and their surroundings. Hasty judgment as to the harmful or beneficial attributes of a mammal is often erroneous,

¹ This publication is a revision of Department Circular 59, Suggestions for Field Studies of Mammalian Life-Histories (20).² In the preparation of new material to supply the demand for information of this character, in view of the increased interest in and consequent development of the subject, it has seemed desirable to modify and expand the method of treatment.

² Italic numbers in parentheses refer to Literature Cited, p. 11.

and life-history studies are necessary for sound guidance. Effective conservation of the beneficial and the control of the harmful kinds of mammals depend on adequate knowledge of their habits.

To the student the benefits of intimate acquaintance with the living things about him can scarcely be overestimated. Moreover, a widespread appreciation of nature, with the resulting inspiration to rugged and healthful thinking and living, has an important bearing on our national welfare.

RELATION OF FIELD AND LABORATORY METHODS

In the study of mammalian life histories, the use of both field and laboratory methods is abundantly justified. The possibility of a complete control of certain environmental factors under laboratory conditions sometimes leads to undue enthusiasm for this type of research. The value of laboratory investigations, however, may often be lessened by a loss of the normal response of the mammal.

With some mammals, which are of such size, number, and temperament that laboratory work with them is possible, studies like that of Yerkes (21) with the dancing mouse may be counted on to yield results of the highest importance in respect to such problems as sense development and discrimination, habit formation, learning ability, and modifiability of behavior. The work of Sumner (18), although largely concerned with problems of genetics, has afforded much information of value in studies of life history. Many mammals, however, can not be so easily brought into the laboratory or successfully kept in captivity. The ideal method is for a student of mammalian life histories in the field to carry his investigations into the laboratory whenever possible. The two fields are so vast and specialized, however, that this is rarely practicable. If adequate conclusions as to behavior under actual living conditions are to be reached, it is necessary to associate work in the laboratory with direct observations of the animal in the natural state; and many of the most important details of animal life histories can never be learned in the laboratory.

Two authorities on this subject may be quoted here: Ritter (12, p. 403) says, "the future's progress in the biological sciences will be accomplished by a far closer, more vital interdependence between researches out in nature and researches in the laboratory." Roosevelt (13, p. 11) states, "it is essential to recognize that the best scientific men must largely work in the great out-of-doors laboratory of nature. It is only such outdoors work which will give us the chance to interpret aright the laboratory observations."

EQUIPMENT

Equipment needed for field investigations of habits of mammals varies all the way from tools that are available almost everywhere to the complicated and expensive instruments necessary to the solution of more difficult problems (1). Pick, shovel, ax or large hatchet, trowel or large spoon, brush cutter, grasscutter, tapeline, sketch pad, coordinate paper, and writing materials usually suffice for beginning studies.

Less refined modes of inquiry should give way as rapidly as practicable to intensive investigations of a quantitative character. There

is great need for the development of the ecologic method of approach in the study of the animal and its environment. Field plot or quadrat methods should be combined with observations on the behavior of animals under confinement, the whole based on a thorough knowledge of normal field conditions over wide areas. No attempt is here made more than to refer to the development of this important side of the work, with the permanent field stations, specially trained personnel, and comparatively elaborate equipment that it implies. Development of new methods of study is one of the most important and promising lines of work in the entire field.

The increasing employment of the camera in the study of habits is peculiarly desirable. Chapman (*β*, *p. 1*) thus states the case for the scientific value of bird photography:

There are certain matters, such as a bird's song, its time of migration, etc., which must be set forth with the pen; there are others, such as its haunts, nesting site, nest, eggs, the appearance and development of its young, where the camera is so far ahead of the pen in its power of graphic representation that it is a waste of time to use the former when circumstances permit the utilization of the latter.

Though much less used in connection with mammal study, perhaps because of the nocturnal habits of these animals and the lesser accessibility of their haunts and homes, the value of the camera in this province can scarcely be overestimated. Photographs should be obtained of living animals in characteristic attitudes, of specimens, especially those freshly killed, of animals in traps, of characteristic food plants or other vegetation, and of noteworthy features of topography or environment. Photographic record is desirable also of tracks of animals, their systems of runways, beds or shelters, nests, piles of stored food or "hay," feces, claw and tooth marks on trees, cropped vegetation, and general habitat. The animal-portrait work of the day is of such high character that ordinarily it will not be possible for the biologist in the field to attempt to equal it; but it is of such importance that wherever possible a professional animal photographer should be a member of a field party.

IMPORTANT DATA

PREPARATION FOR WORK

The study of mammalian life histories opens a field of activity for any sincere student with an enthusiasm for closer acquaintance with wild life. No human being and no book, but nature herself, is the supreme authority in natural history. The beginner as well as the veteran investigator may make important observations, although the most adequate training in scientific method and technic and broad experience are desirable for work on habits. At best, one can read all too little in "Nature's infinite book of secrecy."

ENVIRONMENT AND HEREDITY

In a very real sense the mammal is the product of its surroundings, which on every side influence the individual, the community, and the species. Although there have been prolonged, critical, and thorough-going studies of heredity, similar investigations of the environment are for the most part lacking, so that the exact rôle

of environment in the evolution and life of mammals is unknown. The numerous significant and interesting studies in genetics and heredity seem to have resulted in an unwarranted emphasis on the power of heredity, often at the expense of environment. It is probable that field biologists, though conceding at once the enormous importance of heredity, generally are in agreement with Jennings (9, p. 48):

Any characteristic requires for its production both an adequate stock of chemicals and an environment adequate for its production through proper interaction of these chemicals with one another and with other things. In these senses all characteristics are hereditary and all are environmental, but no characteristic is exclusively hereditary or exclusively environmental.

and (9, p. 57-58)—

Heredity is stressed as all powerful; environment as almost powerless; a vicious fallacy, not supported by the results of investigation.

It is clear that the study of the relation of the environment to the development, structure, and habits of the living form is as well worthy of critical and prolonged attention as that which has been given to heredity in the past few decades. Results obtained from experiments with plants by Clements, MacDougal, Hall, Garner, and others are extremely suggestive of lines of activity that should be carried on with mammals and other animals, as well as with plants. For complete success such investigations are dependent not only on critical experimental treatment, but also on extensive and careful field surveys and life-history studies of the forms considered. Studies of environment and its influence on mammals and on vertebrates generally have no more than been begun but promise much for the future of biological science. Investigations in this province depend primarily on critical observation and analysis of life histories.

INFLUENCES ON ENVIRONMENT

The environment not only influences the mammal, but the mammal influences its environment through its multitudinous activities, as in loosening soil by burrowing and in excavating dens, burying rocks, packing soil by tramping and trail making, collecting materials for nests, building dams and flooding valleys, and scattering and planting seeds or destroying seeds and vegetation. Incorporation in the soil of organic materials, such as skin, bones, flesh, and excreta, also may be included in these activities. Of course, the influence of one or of a few mammals ordinarily counts for little, but when the aggregate work of thousands and even millions of individuals is taken into account the effects on environment are without doubt, in many instances, of great importance. The soil-building and fertilizing, or even the soil-destroying, rôle of different burrowing and terrestrial mammals remains to be determined. Christy (4), Bell (2), and Grinnell (7, p. 145) have already drawn attention to the significant parallel between the pocket gopher of North America and the earthworm in England, as regards their work in soil formation. Studies of this and related subjects should be carried forward on a much broader scale than heretofore. It is inevitable, in the study of life habits, that effects of mammals on their surroundings should assume a prominent place.

RELATIONS OF MAMMALS AND PLANTS

The influence of mammals on the distribution of plants is doubtless far more pervasive and important than has been realized. A significant intensive ecological study of the vegetation of a particular area has been made by Farrow (6) in England. He writes (6, p. 104):

Apparently the presence of rabbits alone is sufficient to change the potentially dominant plant on Cavenham Heath from *Pinus sylvestris* [Scotch pine] to *Pteris aquilina* [brake] through a large number of various stages. . . . The passing of England from a forest period into a grassland period may of late have been accelerated by the influence of rabbits.

With the modified conditions brought on in the United States by lumbering, grazing, and agriculture, the relations of the native mammals to forest and forage are often fundamentally changed. In some localities the maintenance of a sustained yield of forest and forage, or the successful operation of specialized and intensive agricultural enterprises, will ultimately depend in large measure on the solution of problems in the life history and control of various mammals. Unfortunately the significance of mammals (and of vertebrates generally) in these matters has been generally neglected, as a perusal of projects and bibliographies shows. To work out these relations is manifestly impossible without close attention to mammalian life histories.

LIFE HISTORY OF MAMMALS

The suggestions (pp. 7-8) for studying the life history of mammals are divided so as to be applicable to the individual animal in its youth, maturity, and old age. Habits are known to change considerably at different stages of life, and such a division seems logical and justified by the demands for an adequate picture of the developing mammal.

After the principal life-history stages of the mammal are studied, its structure and behavior are scrutinized more closely. Of special interest to the student of life habits are the form of the body as related to habits, special or noteworthy structural developments, and adaptations. Perhaps most of the work of the student of life histories, however, will be devoted to the behavior of the mammal, principally in nature, secondarily in the laboratory. Such points as the disposition and temperament of the mammal, its senses, means of intercommunication, times of activity and leisure, movement, eating and drinking, breeding, sanitation, flocking, hibernation, migration, and adaptation or nonadaptation are the very essence of life-habits study.

RELATIONS OF LOWER MAMMALS AND MAN

Finally the relations of the lower mammals and man are considered. The means of finding and counting mammals are referred to, and the direct and indirect relationships hinted at. These relationships include the important effects of man's activities on wild mammals, and, conversely, the effects of the mammalian activities on man's interests. There is also suggested the possibility of undeveloped mammalian resources, as of flesh for food and fur or hides for clothing.

SUGGESTED STUDIES

The points incorporated in the outline that follows are some of those concerning which additional detailed information is desirable. No one person can hope to acquire full information on all the items listed. The suggestions serve as a guide to what should be sought in the course of field work. They should also serve to encourage the recording of many facts that come to the notice of the observer, facts that are not ordinarily recorded because of their supposed unimportance. In general, the main headings alone will adequately serve the purpose of the investigator. In particular instances, however, the details listed under each heading may be found useful.

No attempt is made to present a complete catalogue. Several legitimate fields of inquiry to which contributions can be made by field workers are omitted entirely; for example, the relation of habits to bodily structure. Almost any one of the suggestions included can be followed up and expanded with pleasure and profit (5, 15), and will be found to possess a surprising degree of interest and often of practical importance.

For information regarding habits of the various mammals, the student is referred to Seton's *Life-histories of Northern Animals* (14), his *Lives of Game Animals* (16), to Nelson's *Wild Animals of North America* (10), and to the results of many special studies, including those portrayed in the *Journal of Mammalogy* and other scientific periodicals.

ENVIRONMENT

A. Physical surroundings.

- (1) Soil—kind, composition, texture, color, depth; chemical reactions, temperature and moisture at different depths; topography of region; general suitability for mammalian occupation or use; sand dunes, rocks, cliffs, caves.
- (2) Water—nearness, depth, composition, chemical reactions, currents, light, temperature, snow, ice.
- (3) Atmosphere—pressure, movements, temperature, moisture, light.
- (4) Changes in physical surroundings—relation of age-long changes in topography and climate to the development, migration, establishment, isolation, and extinction of the mammalian community.
- (5) Physical environment in relation to daily and seasonal activity—effects of weather, climate, and daily and seasonal cycles on the activity of the mammal, on hibernation, estivation, or other periodic phenomena, on nocturnal and diurnal activities, and on migration (regular or irregular); effects of long days, very dark days, full moon, dark of the moon, and similar phenomena on habits; hours of activity and rest on part of different mammals; times of appearance and disappearance, as of bats.

B. Plant surroundings.

- (1) Plants of the land—above and below the surface; plants of the water.
- (2) Food and shelter relations between mammals and plants.
- (3) Mammals as disseminators of plants.
- (4) Mammals as checks on plant growth, as enemies of plants.
- (5) Plants inimical to mammals—poisonous plants; infection and transmission of bacterial diseases to mammals and man; periodicity of contagious diseases in mammals; degree and rapidity of recovery; manner of recovery, natural medicines, healing substances or activities.
- (6) Relation between development of plants and animals.

C. Animal surroundings.

- (1) The mammal and its animal associates—in air, soil, water, trees, or on land; in burrows, dens, shelters, nests, trails, about water holes, salt licks, stamping grounds, or elsewhere.
- (2) Relation of the mammal and other animals—relation to others of same kind, to friends, partners, parasites, prey; competition and adaptation among animals; symbiosis, commensalism, warfare, as illustrated among mammals and their associates.
- (3) Animal-caused disease—effects; infection and transmission to other wild mammals, domestic animals, or man.
- (4) Relation of the individual mammal to the development of the community.

INFLUENCE ON ENVIRONMENT

A. On physical surroundings.

- (1) Incorporation in soil of organic animal materials—such as skin, hair, bones, antlers, horns, other organic materials, feces, urine.
- (2) Digging—formation of tunnels, holes, hollows, mounds; burial of rocks, logs, grass, or other objects by excavated materials; extent of cultivation of soil, the plowing effect of burrowing mammals; reduction of ditch banks, stream banks, or other topographic features by burrowing; general effects on erosion, beneficial, neutral, harmful; dimensions of tunnels and chambers, volume of earth removed.
- (3) Packing of soil by tramping or trail making.
- (4) Dam building and flooding of valleys.
- (5) Collection of materials for nests, with subsequent decay and soil building.
- (6) Effects on the soil of dissemination, planting, or removal of vegetation by mammals and of burying fertilizing materials.

B. On plant cover.

- (1) Use of miscellaneous plant parts, as grass, stems, roots, leaves, twigs, or seeds for food, shelter, or nests—mammal-caused zones of vegetation about burrows, water holes, and other areas of concentration; activities of mammals in gnawing bark and eating cambium, girdling trees, peeling bark from trunk or branches, or cutting down plants or trees.
- (2) Dissemination, planting, or covering of vegetation by mammals.

C. On animals.

- (1) Capture and eating of prey—eggs, young, or adults of birds and reptiles; young or adults of mammals; of insects, fishes, mollusks, crustaceans, and other groups.
- (2) Scattering of parasites or associated species.
- (3) Removal of vegetation—which often profoundly affects the other members of the community through disturbing their food and shelter relations.

LIFE HISTORY

A. Youth.

- (1) Birth—date, manner, and place of birth; weight of young and parents.
- (2) Number of young in a single litter; number of litters a year.
- (3) Structure and behavior—adaptation to protection and survival.
- (4) Growth—stage of development at birth; appearance of the skin, eyes, teeth, hair; senses; manner and rapidity of growth; date weaned; date of leaving nest; earliest age at which young are capable of survival without parents; date of achieving mature growth; age of sexual maturity; date of breeding.
- (5) Parental relations—condition and habits of young at birth as related to habits of parents; modes of feeding, carrying, and protecting young; manner of keeping young warm; special habits and instincts related to care of young; maladaptations in behavior toward young, as smothering or eating them; attitude of males toward young.
- (6) Enemies of young—severe weather and other physical phenomena; plant and animal enemies; diseases, parasites, insects, rivals, competitors; modes of opposing and escaping enemies; mortality rate of young.

B. Maturity.

- (1) Breeding—structures and habits as related to breeding; territory or home range; methods of procuring mates; evidence of sexual selection; courting antics; love songs or calls, color, behavior, odors as aids to mating; relations and relative numbers of the sexes; normal or abnormal increase, evidence of extraordinary reproduction; groupings or aggregations of young or old males, pregnant females, or others; dates of heat and copulation, associated habits; condition and distribution of mammae (mastology); length of period of gestation; length of suckling period; hybridization between related species; strength and duration of mating and family ties; polygamy, polyandry, promiscuity, monogamy; acquisition of harem; relation of parents to family; details of habits of parents during period of dependency of young; dates and manner of acquisition and loss of antlers or other structures related to breeding.
- (2) Nests, shelters, and other places of resort—natural resorts at different seasons; shelter chambers, bowers, lairs, dens, forms, beds; nests, storage chambers, chambers for deposit of excrement or for other purposes; purpose of nests, individual nests, associated nests, unoccupied nests; approaches to nests, trails, burrows, tunnels, runways; protection of nests through closing burrows or in other ways in the daytime or at night; habits associated with nest approach; regularity of use of bedding or nesting places; earth packing in burrows; isolierungs, or earth plugs, their structure and function; extent of den expansion; temperature studies of burrows and nests under different climatic and other environmental conditions at different depths and at different times of day, season, and year; numbers, plan, elevation, measurements of nests and nest chambers; technic for excavating and mapping dens; for reproduction or making casts of tunnels; measuring length and volume of tunnels; taking temperature of tunnels.
- (3) Structure and behavior of mammals in nonbreeding condition—structures and habits observable in fall and winter; temperament, adaptations enabling mammal to endure stress of seasons; postbreeding migration, dispersal of families, flocking, wandering, food getting.
- (4) Other features in structure, behavior, or relationship peculiar to mature adults.

C. Old age.

- (1) Effect of old age on structure and behavior—hermits or recluses among mammals.
- (2) Food and shelter of the old.
- (3) Enemies, competitors, associates, means of cooperation and protection.
- (4) Length of life; time, place, and manner of death.

STRUCTURE AND BEHAVIOR

A. Structure.

- (1) Form of body—proportions, contour, weight, dimensions.
- (2) Special or noteworthy developments—head, trunk, tail, limbs, hands, feet, skin, hair, muscles, bones, glands, protective armor, sense organs, other noteworthy features.
- (3) Periodic structural changes—changes with age; periodic sexual changes; changes with season, molts, growths, and loss of special appendages or organs.
- (4) Adaptations—overdevelopment or underdevelopment of bodily parts; markings or coloration—concealing, disruptive, directive, warning, mimicking; structures formerly beneficial, now harmful.

B. Behavior.

- (1) Disposition and temperament—individuality, gregariousness, intelligence, instinct, attitudes, strength, vitality, endurance, tenacity of life, courage, esthetic sense, sociability, playfulness, games, expression of emotions, moods, curiosity, memory, property instinct.
- (2) Senses—time and degree of development; reactions to sound, light, odor, taste, touch, balance; devices for appealing to senses, as

B. Behavior—Continued.

- voice, glands and their secretions (hip glands, metatarsal glands, back glands, belly glands, musk glands, foot glands, anal glands, sex glands); special sensory structures, as hairs, vibrissae, rhinaria, specialized skin; fleshy tactile appendages; attitudes in listening, touching, sniffing, looking, tasting; kinesthetic sense; orientation.
- (3) Means of intercommunication—call notes of location, appeal, terror, courting, alarm, challenge, warning, concealment; barking, baying, screaming, howling, squeaking, squealing, singing, tapping, drumming, purring, roaring, bugling; warning attitudes; flash signals; emission of glandular secretions; odors and odor posts; touch.
 - (4) Times of activity and leisure—hours of beginning and ending daily activity; times of appearance and disappearance, as of bats and other nocturnal species; unusual activity, as nocturnal species by day or diurnal species by night; hours of work, rest, sleeping, feeding, drinking; effects of weather on activities; attitudes and conditions when sunning, basking, sleeping; differences in activities caused by temperature, moisture, seasonal food supply, or breeding.
 - (5) Movements—in running, jumping, climbing, digging, swimming, flying; gaits, speeds; length of strides, height of jumps; endurance; holding or balancing objects; manual, pedal, or caudal dexterity; habits or tricks for protection or direction; time and range of travel; regularity of use of same travel way.
 - (6) Eating and drinking—list of foods eaten indicating range of adaptability; foods at different seasons; food preferences; need for salt or other mineral materials; need for roughage; conveyance and storage of food; periods when stored food is used; food caches, as of mountain lions, bears, or rodents; times of harvesting and feeding; variations and reasons therefor; capacity for carrying or dragging food; quantities carried in cheek pouches, mouth, or paws; cleaning or washing of food; hay making and storing; quantities of food stored and eaten; effects of food getting on plant and animal surroundings; manner of capture of prey, chasing, sudden charging, lying in wait; manner of killing prey; migration or movement in relation to prey; disposition after killing; portions eaten; manner of eating; cannibalism; dependence on water; time and manner of drinking; associated habits.
 - (7) Sanitation—cleanly or uncleanly habits; place of urination and defecation; condition of dens, nests, burrows, trails; bathing—dust baths, mud baths, sun baths, water baths; care of fur or hair, scratching, combing, cleaning, biting, personal toilet.
 - (8) Flocking or nonflocking—solitary habits; gregariousness; associations of the same or of different kinds of mammals in pairs, groups, flocks or herds; whether flocks are built about the family or are groupings of individuals according to age, sex, or other conditions; advantages of flocks; comparison of behavior of individuals alone and in flocks; mob psychology; coordination of activities in flock, synchronous responses to same stimulus.
 - (9) Hibernation, estivation, and other periodic phenomena—dates of entering upon and emerging from hibernation and estivation; causes of hibernation and estivation, as related to altitude, climate, soil, physiology, food, and water; weight, activity, and other characteristics of animals before, during, and after such period; details as to completeness or incompleteness of torpidity; occasional dormancy (controlling factors); movements or activities, and intermittent waking while hibernating or estivating; place of hibernation or estivation; habits associated therewith; body temperatures of hibernating or estivating mammals at different periods; temperatures of hibernating or estivating chambers, comparisons with outside temperatures; seasonal changes in food, in feces; hibernaria and other technical equipment for studying hibernating animals under controlled conditions.
 - (10) Migration—movements of mammals, especially of bats, before and after breeding; dates of appearance and disappearance; extent and direction of movements, local and general; causes of migration,

B. Behavior—Continued.

food supply, climatic, physiological; unusual migratory movements, as the spasmodic irruptions of lemmings, and mouse plagues, with causes.

- (11) Adaptations and maladaptations—intelligence; overdevelopment and underdevelopment of instinct; beneficial and harmful instincts; cooperation; movements and attitudes, freezing, slinking, running, crouching, hiding, trailing; shelter ways or avenues of retreat; conspicuous adaptation or lack thereof to new conditions; habits formerly beneficial, now harmful.
- (12) Miscellaneous peculiarities of habit—carrying propensities, as of wood rat; scratching and rolling habits, as of wolf, coyote, and mountain lion; other peculiarities.

LOWER MAMMALS AND MAN**A. Finding and counting mammals.**

- (1) Means of detecting presence of particular species—form of tracks, distances between footfalls, differences in tracks with various speeds or movements, tracks in mud, dust, sand, snow; feces (scatology), shape, size, color, composition, place of deposit, abundance; claw marks on trees, logs, or ground; tooth marks on wood or bone; wallows, dust baths, beds, forms, nests, shelters, runways, holes, trails, yards, "using" places; cropped or harvested vegetation.
- (2) Numbers—present and former numbers; methods of taking censuses; counts on transects or unit areas; trap-night, live-trap, standard-bait, and poisoning methods of making counts; judging numbers from records of individuals seen, or from enumeration of tracks, feces per unit area, burrows, mounds, dens, nests, vegetation or other materials consumed, or other evidences of presence; fluctuations in numbers from year to year and causes of fluctuations; pathogenic agencies; adverse or favoring conditions, drought or flood; effects of disease and other natural checks; manner and rate of increase in numbers.

B. Direct relations between mammals and man.

- (1) Effects on mammals of man's activities—increase or decrease in numbers due to man's occupation and invasion of new ranges, with changes in habits, involving changed relations to human welfare; effects on numbers, habits, and distribution of mammals of agriculture, railroad and bridge building and maintenance, fencing, hunting, grazing, lumbering, plowing and irrigating, forest fires, protection of certain species of game or other classes, killing pest species, as predatory carnivores and rodents; effects of captivity.
- (2) Utilization of game and fur species—present and former numbers; methods of conservation and management; manner of handling local legislation; hunting and trapping methods.
- (3) Undeveloped mammalian resources—flesh for food; fur or hides for clothing; other useful mammalian products; possibilities and difficulties of domestication or semidomestication or use of additional beneficial wild species.
- (4) The mammal pest problem—mammals harmful to various interests; balance between harm done and possible benefits rendered by alleged pests (value as objects of sport, producers of fur, as sources of flesh for food, or as enemies of other species); details of economic relations, including lists of crops or products attacked, beneficial species preyed on, or of native vegetation or trees damaged; definite data on extent of damage done; economic relations in different seasons; when and where are control methods justified; degree of control necessary on particular areas; methods of control, with details on trapping, poisoning, or hunting methods; relation of mammals to public health, with data on parasites or disease germs carried by them and other susceptible animals (e. g., relation of rats and ground squirrels to bubonic plague; of rodents to Rocky Mountain spotted fever; of coyotes and other mammals to rabies; of rabbits, coyotes, and others to tularemia).

CONCLUSIONS

Any department of natural history, if studied with the proper research spirit, is replete with interest. But none, perhaps, promises a greater return in real satisfaction than the field study of the home life of wild vertebrate animals (8, 16, 17, 19). Reference has already been made to the practical importance of the investigations and their occasional direct bearing upon problems in other lines of inquiry.³

It is universally conceded that the work throughout, to be done well, must be founded on an adequate taxonomic basis; but the time has arrived when a new emphasis may be placed on the intensive study of the living animal in its natural environment.

The outline presented in this publication will indicate the richness of the field. To do it justice, the work of many individuals and institutions throughout the country will be required. On the taxonomic side each State should have at least one representative collection of the mammals and other vertebrates to be found within its borders. The building up of private collections should likewise be encouraged. There are still great gaps in the material representative of the larger groups of mammals and of most of the smaller ones, even in the larger collections in this country.

But the incompleteness in our information regarding life histories is even more conspicuous. Universities, colleges, normal and high schools, State scientific surveys, national, State, and city museums, and national and State associations and commissions for the protection of fish and game, as well as the United States Department of Agriculture, all have an opportunity to serve their respective constituencies and the country in this field.⁴

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³ These related lines of inquiry include problems in agriculture, forestry, range management, geographical distribution, phenology, migration, ecology, physiology, medical zoology, behavior, game protection and the conservation of natural resources, morphology, heredity, organic evolution, and economic zoology.

⁴ The Bureau of Biological Survey, U. S. Department of Agriculture, solicits correspondence from any individual or institution planning work on the relationship or life histories of mammals or birds, and will be glad to assist with advice or suggestions as opportunity may be given.

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