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Current problems in mammalian ecology and the basic development tendencies in ecology are discussed on the basis of analysis of materials from the IVth International Theriological Congress.

The extraordinarily broad development of ecological studies worldwide makes detailed analysis of the state of the main trends in this field of knowledge practically impossible. Therefore, an exposition of the most important problems and developmental tendencies in ecology based on material from major international meetings (congresses, conferences, symposia, and so forth) seems sufficient. Such an analysis is regularly presented in the pages of the journal *Ekologiya* (Shilov and Bol'shakov, 1979; Shilov, Bol'shakov, and Kryazhimskii, 1983). This report is devoted to the IVth International Theriological Congress (13-20 August, 1985, Edmonton, Canada).

The congress assembled 954 participants from 58 countries. Preparations for the ITC were made by the Central Council of the Theriological Section of the International Union of Biological Sciences (IUBS), headed by its president, Academician V. E. Sokolov (USSR). The national committee of the IVth ITC included prominent Canadian zoologists; the duties of chairman of the secretariat were performed by Prof. V. A. Fuller (University of Alberta, Edmonton, Canada).

The scientific program of the ITC consisted of plenary lectures, symposia (oral reports and poster sessions), working groups, business meetings on special problems, scientific films, and photographic exhibitions. Twenty-nine symposia and 21 working groups were devoted to mammalogical problems.

Ecological studies occupied a dominant position in the proceedings of the ITC. In the symposia and working groups, 450 reports were given in the form of lectures and poster displays. In addition, a general discussion was conducted of several problems, including ecological ones, not formulated in official reports. As is shown in Table 1, more than 65% of the official reports of the congress were devoted to theoretical and applied aspects of ecology. A number of works on methodology should be added to this, as well as practically all the works on the conservation of mammals, since such measures are based on study of the ecology of the protected species.

Reflecting the current developmental tendencies in ecology, the greatest number of presented works was devoted to various aspects of population ecology (Table 2). More than half of these concerned various aspects of the population structure of different species and population dynamics. These problems are closely related and of interest to scientists because of their great theoretical (the concept of a population as a self-supporting biological system, the actual form of existence of species under specific ecological conditions) and practical (the control and prognosis of numbers of economically important species) significance. At the congress, results were presented from long-term field studies using current methods for individually marking animals and using computers for data processing. The most outstanding theoretical papers were also devoted to this problem: on demographic models as a method for understanding population processes (M. Conley, USA), on the role of dispersion and cyclic populations (C. Krebs, Canada), and on the mechanisms of population homeostasis maintenance (I. A. Shilov, USSR). In view of the great complexity of population systems, the problem of population dynamics cannot be considered as solved. In the special working group on the major problems of mammalian ecology, this question aroused particular interest and was recognized as deserving serious attention.

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TABLE 1. Analysis of the Distribution of Reports in the Symposia and Working Groups by Section of Mammalogy

Section	Number of works (%)	Notes
Ecology	450 (65,3)	Including 50 on applied aspects (7.3%)
Paleontology	35 (5,1)	
Systematics and phylogeny	71 (10,0)	Including 15 on zoological collections
Zoogeography and faunistica	28 (4,1)	
Ethology	14 (2,0)	
Morphology	19 (2,8)	
Methodology	26 (3,8)	Predominant methods for marking and age determination
	25 (3,6)	
	21 (3,0)	
Conservation		
Other		
Total	689 (100)	

It should be noted that, against the background of the avalanche-like growth of factual material, there is an obvious lack of synoptic works analyzing the general laws of population structure and dynamics. Such studies are extremely important for practical control of the numbers of economically significant species, and the need for their development and expansion seems obvious.

In comparison to previous years, there was a marked tendency toward a broadening of studies of the role of mammals in ecosystems. A major problem is the mammal-plant interrelationships. Intensification of work in this area is determined by the need for an effective solution to the critical problem of pasture use and of the reproduction of ungulate stocks, including rare and protected species. We note that it is precisely the feeding physiology of herbivorous mammals (predominantly ungulates) that is foremost in the field of physiological ecology.

The development of studies of the structure and dynamics of ecologically close mammalian species (rodents), along with their theoretical significance (competition and the means of its reduction, the possibility of sympatric species formation, and so forth), is stimulated by the practical importance of the organization of effective, simultaneous control of the numbers of several species in natural infection centers in agricultural and urban areas, and so forth.

As in the past, much effort is being directed toward the study of various aspects of ecological physiology. A new development in this direction is the revival of research in the area of feeding physiology (mainly of herbivorous animals). On the one hand, this is clearly connected to the intensification of research on the relationships of ungulates with pasture vegetation (as already mentioned above). On the other hand, the renewal of interest in feeding physiology is also due to a tendency toward a broadening of research on the energetic assessment of the role of particular species in the dynamics of matter and energy in communities; the share of works on the heat exchange and energetics of organisms of different species and mammalian groups is correspondingly large. A series of works is specifically devoted to the problem of cold adaptation, which is relevant for a number of northern countries.

New trends closely related to progress in population ecology have developed in the area of physiological ecology: the study of the physiology of communication systems (for mammals, mainly the olfactory system); and the study of behavioral mechanisms that perform general population functions. It is precisely this "ecologization" of the problems and methods of study of behavior which underlies the decrease in the number of works that can be considered as classical ethology.

Works in the area of applied ecology have developed quite steadily. The relatively small share of such studies presented in Table 2 does not completely reflect their real importance. First, many autecological works are conducted on economically important species with purely applied objectives. Second, the data in the table do not include material from a special, extensive symposium on the reindeer and caribou. The basic trend in applied ecology remains the development of the scientific bases of effective pest control and of the rational management

TABLE 2. Analysis of the Themes of Ecological Works

Problem and its individual aspects	Number of works (%)	Notes
Autecology	103 (22.9)	Habitat distribution, form of life, daily activity, reproduction
Rodents	32	
Lagomorphs	17	
Ungulates	23	
Carnivores	11	
Marine mammals	9	
Others	11	
Ecological physiology	63 (14)	Physiological and ecological aspects
Feeding	24	
Thermoregulation	17	
Organismal energetics	8	
Other	14	
Population ecology	142 (31.6)	
Population structure	51	
Population dynamics	37	
Role of behavior	7	
Communication	12	
Genetics	16	
Other	19	
Role of mammals in ecosystems	92 (20.4)	
Relationship to vegetation	20	
Predator-prey	10	
Parasite-host	9	
Associations of closely related species, competition	23	
Other	4	
Anthropogenic influence	21	
Feral species	9	
Applied ecology	50	
Pest control	24	
Hunting, animal farming	16	
Game breeding	10	
Total	450 (100)	

of hunting and trapping. Practically no works were presented on the ecological bases of medical mammalogy: these questions were indirectly touched on only in the plenary lecture by T. Yu-ill (USA) on the role of pathogenic agents as components of mammal associations. Such a situation hardly reflects the actual state of research on this problem. Extensive studies on this topic are being conducted in our country. It is regrettable that the Soviet Ministry of Health did not take the opportunity to display the successes of Soviet science in the proceedings of the ITC.

Questions on the biology and economic utilization of particular, economically important species of mammals occupied a very important place at the ITC. Many papers in the ITC program were devoted to ungulates. Foremost among these were reports on the biology and economic utilization of the bison and muskox, which were presented mainly by Canadian and American mammalogists. At present, the bison in North America is maintained basically in a semi-free state; there are 85-90,000 individuals, less than 10% of which live in the wild (A. Hawley and R. Bannage, Canada). Studies of its biology involve herd hierarchy, territorial use, habitat selection, and so forth. Analogous research is being conducted on muskox biology. Although an association for the utilization of the muskox in Alaska has existed for about 30 years (with an administrative center in Anchorage, a muskox breeding farm, and plants for processing the hair), real use of the species for improvement of the living conditions of the peoples inhabiting the Arctic is quite problematical (J. McDonald, USA). Breeding in captivity is not completely successful due to a combination of biological, sociological, and economic factors. The price of fencing material and supplemental feed is high; export of the end product is limited. The difficulties begin with the complexity of forming a herd with individual muskoxen (R. White, USA).

Among the ungulates, deer apparently have the greatest commercial value. They are intensively bred on a large scale, predominantly in China, New Zealand, South Korea, and the Federal Republic of Germany: about 3,000,000 axis deer, 170,000 red deer, and 65,000 fallow deer. Data were presented in reports on the utilization of deer in a number of specific countries: New Zealand, Australia, Japan, and others. Thus, in Australia about 12,000 fallow deer are maintained in captivity; the majority of the farms are small, less than 100 head, but they are profitable because of the high price of venison. In Canada, a new field of husbandry has arisen, wapiti breeding, which is quite profitable, but which has significant complications with winter feeding on the farms and ranches. In New Zealand, it is estimated that there will be 1,000,000 deer on farms by 1992. Also of interest is the information of Chinese zoologists on the commercial hybridization of wapiti with sambar: the export of antlers (the main form of export) from hybrids is 16.5% greater than from wapiti and 54.5% greater than from sambar. However, the disease resistance and adaptability of the hybrids is lower than that of either of the parents (Zhou Shilang, Peoples Republic of China).

Interesting reviews of the biology and utilization of the wild boar were presented by Polish colleagues and scientists from other European countries. The basic trends in this research are on feeding characteristics, behavior, herd structure, reproductive characteristics, the characteristics of digestive-tract enzymes, and the role of introduced animals in biocenoses.

Notable among the small number of reports on the European elk is the joint paper by a group of Norwegian and Swedish scientists on the factors influencing the take of elk in Scandinavia: the annual take grew from 55,000 in 1975 to 190,000 in 1982 (growth was particularly rapid in taiga regions), due to hunting selectivity, the absence of predators, and change in forest composition (B.-E. Saether et al.).

Reports on other species of commercially valuable animals (beaver, mustelids, fox, wolf) were dominated by material on population social structure, reproductive biology, territorial use, and behavior. Of particular interest to Soviet investigators is an attempt at biological control of an island population of the Arctic fox (E. West, USA). Introduced to the Aleutian Islands, the Arctic fox, having no natural enemies there, inflicted serious damage on the seabird populations. Attempts to limit their numbers by trapping, shooting, and poisoning had only limited success. In 1980, work began with the release of sterile red foxes which, as larger and more aggressive animals, should force the Arctic fox from the islands.

The problems of ecology were most completely examined in the following symposia: "Population Biology," concerning the features of population structure, the mechanisms of its formation and maintenance, the population dynamics of different groups of mammals, and the general principles of "life strategy" and its relation to the ecology of specific forms; "Effect of Parasites and Disease on Mammalian Populations," on questions of general parasitology and the effect of parasites on mammalian populations, and on the numbers and biology of hosts; "Genetic Structure of Populations," on the spatial and genetic structure of populations, the interrelationships of individual populations and their genetic specificity, and the degree of inbreeding and heterozygotism in populations and their stability; "Features of the Structure of Mammalian Communities," on various aspects (not only ecological) of the formation of mammalian community structure, its specific forms, and its connection to features of habi-

itats and interspecific relationships (including competition); "Social Systems," on the forms of sociality in different groups of the class Mammalia and their biological significance; "Variations in Sociality among Carnivores," on the specifics of intrapopulation relationships in felids, canids, ursids, and mustelids, and several other aspects of their ecology (characterized by works on feral dogs and cats, as well as on carnivores in urban environments); "Population Dynamics of Lagomorphs," on various aspects of lagomorph ecology: numbers and their dynamics, population structure, and mechanisms of autoregulation; "Social Systems in Voles of the Genus *Microtus*," on features of the ecological, sex, and age structure of populations in different species of this genus; "Ecology and Feeding Physiology of Herbivorous Mammals," on questions of the anatomy and physiology of the digestive system and of foraging behavior connected with feeding, habitat distribution, and the seasonal dynamics of feeding; "Mammals in Cold Conditions," on the problem of the physiological mechanisms of cold adaptation (thermogenesis and thermoregulation, neuroendocrine adaptive mechanisms, hypothermia, and hibernation).

Notable among the working groups were the following: "Winter Ecology," on questions of thermoregulation, energetics, and population structure during winter in rodents and insectivores; "Mammals as Bioindicators of Environmental Pollution," on general questions of ecological monitoring and specific biological tests that can be used to characterize the level of human alteration of ecosystems; "Major Problems of Mammalian Ecology," an open discussion focused primarily on the need for study of the forms, causes, and mechanisms of cyclical population dynamics, and on the importance of further development of population ecology and physiological ecology, especially reproductive physiology; "Pest Control," on questions of the harmful activity of mammals, the technique of population and damage control, integrated pest control methods, and national programs in this area.

In addition to those indicated, ecological questions were also discussed in other symposia on olfactory biology, the dispersion of small mammals, the biology of beavers, insectivores, and African mammals, and the biology and conservation of marine mammals, as well as in working groups on picas, red voles, rodents, tropical rodents, wolves, canines, bears, mustelids, hyenas, pigs, sirenians, and others.

We will concentrate on an analysis of the proceedings of several of the working groups and symposia.

The working group on winter ecology was led by V. N. Bol'shakov and W. Schmid (USA). The winter ecology of mammals is much less studied than summer ecology: the group essentially examined questions of cold adaptation, the characteristics of basal metabolism and thermoregulation (predominantly reports by American and Canadian scientists), in animals mainly inhabiting the middle latitudes. Only two papers were devoted to the intrapopulation relationships of animals during winter: V. N. Bol'shakov (USSR) on forest voles, and D. Grey (Canada) on the muskox. The discussions and questions also clearly indicate the ecophysiological trend of research.

The working group "Mammals as Bioindicators of Environmental Pollution" assembled more than 40 scientists from different countries. The main papers were presented by scientists from the USSR and USA. The urgency of the problem of using mammals as bioindicators of environmental pollution stems from current ecological conditions and requires the organization of an International Program on Bioindication, which has been supported by UNESCO and the IUBS. The goals and tasks of this program have been formulated (I. Salanki, Hungarian Peoples Republic): the encouragement of scientific and national forms of development and application of methods of bioindication, the collection and distribution of information, the standardization of research methods, and so forth. V. E. Sokolov proposed the wider use of biological preserves for conducting bioindicator studies. A number of reports touched on methodological questions of bioindication, particularly on the requirements for bioindicator species (O. F. Chernova, USSR; E. Kucera, Canada). The scientific papers revealed various trends in bioindication. The report by V. E. Sokolov and D. A. Krivolutskii (USSR) described the principles and methods of using wild animals for the bioindication of global radioactive pollution. At the congress, the problem of the use of mammalogical collections in environmental monitoring was discussed for the first time (S. George, USA). E. Kucera (Canada) reported on the monitoring of metals in mammals in the Province of Manitoba; the American mink and otter were used as bioindicator species. K. McBee (USA) presented a report on the cytological analysis of wild rodent populations for detection of environmental mutagens.

The symposium on mammalian olfactory biology (5 papers and 6 poster displays) was not representative, apparently due to the near concurrence with the ITC of the International Symposium on Chemical Communication (USA, Wyoming, 1985). Several research trends were delineated: the structure of pheromone sources, intraspecific (sexual, marking) and interspecific significance of olfactory communication, and the role of pheromones in the control of pest species. The distribution, structure, and function of specific skin glands have been studied by Indian researchers (M. Balakrishnan et al., India) in several insectivores (*Suncus murinus*) and ungulates (*Axis porcinus*, *Antilope cervicapra*). Marking activity was described in the coyote (R. Crabtree, USA): a method was suggested for the individual identification of scent marks using radioactive isotopes, fluorescent substances, and metals. In picas, the function of the sublingual gland and the relationship of its secretory activity to marking behavior during breeding have been elucidated: mating is successfully accomplished by individuals that know one another (by the scent of the gland secretion) (C. Meany, USA). The role of pheromones in the mating process has been studied in the Syrian hamster (V. E. Sokolov et al., USSR); the authors extensively discuss the problem of artificial pheromone application. Pheromones are very important in mustelid reproduction (R. Apfelbach, FRG). This work is also interesting on a methodological level: the reactions of the animals were recorded automatically by a sensing device. Research is continuing on the specific reaction of ungulates to pheromones, "flemen" (Sokolov et al., USSR; L. Pillai and K. Alexander, India). Chemical communication is being intensively studied in pests such as mice in India (S. Nair et al., India) and Lagomorphs (D. Bell, England).

Research is actively being developed on the role of pheromones in predator-prey relationships. Thus, the paper by T. Sullivan (New Zealand) dealt with the effect of the odors of predators (urine, excrement, and the secretion of anal glands; wolf, fox, coyote, and mustelids); it was demonstrated that the scent of a predator is recognized by the prey, i.e., it serves as an interspecific signal. In mustelids (*Mustela putorius f. furo*), olfactory imprinting on the scent of the prey has been discovered: the imprinting occurs in the third month of life (the "sensitive period"), which correlates with the postnatal development of the olfactory analyzer (R. Apfelbach, Federal Republic of Germany). D. M. Stoddart (Australia) devoted his report to the evolution of the role of olfactory signals from the higher primates to modern man, and suggested the hypothesis that phenomena such as "georgianism" (sexual promiscuity and its consequence, the breakdown of family and matrimonial ties) result from the loss of the individual odors (due to the reduction of scent glands in humans, hygiene, the use of deodorants, and so forth) of sexual partners. We note that Stoddart did not dwell on the social and class roots of this phenomenon.

In connection with the preparation of a Soviet-Cuban monograph on the morphology of the manatee (Nauka Press, 1985), it is appropriate to analyze the results of the proceedings of the working group "Siernia: Biology and Conservation" (7 papers and 26 posters). All aspects of the biology of the manatee (*Trichechus manatus*) are being intensively studied in the USA in the state of Florida: studies are being conducted on the morphology of the gastro-intestinal tract (L. Hurst), and radiographic age determination is being made using the bones of the forelimbs (A. Watson). A majority of the reports concerned distribution, estimation of numbers, conservation, and the utilization of manatees. The main paper, "Sirenians, Past, Present and Future?", was presented by D. Domning (USA). T. O'Shea (USA) presented the problem of the interrelationship of the physiology, behavior, and evolution of sirenians and their level of brain development for general discussion. J. Johnson (USA) gave a review of sirenian brain research. Also examined were questions of winter movements and population structure (N. Thumser, USA), management and conservation of populations (A. Smith, USA), manatee distribution in Puerto Rico (C. Rathbun, USA), the use of telemetry for radiotracking manatees (J. Reid, USA), and strategies for the rational utilization of sirenians (J. Packard et al., USA). Sirenian parasites are being studied in detail (C. Beck, USA); thus far, four species of trematodes, one species of nematode, one protozoan, and two species of crustacean ectoparasites have been found in manatees. Data was presented which indicated that only 11.7% of the manatees in Florida die from natural causes; all the remaining mortality is directly or indirectly the result of human activity (T. O'Shea, USA). G. Rathbun (USA) compared the behavior of the manatee and dugong and discovered significant differences; dugongs gather in large herds, while manatees live in small groups; dugongs, in contrast to manatees, are characterized by sexual dimorphism and mating displays. The author discusses these differences from the viewpoint of morphological structure, physiology, and predator pressure. Among the other ethological works was an interesting report on mother-pup relationships in the manatee, particularly individual identification, which apparently occurs with the aid of vocalization (T. O'Shea, USA). A comparative

study has been conducted of the behavior of free-born and captive-born manatees (B. Barnier, USA). One report was devoted to dugong numbers (H. March, Australia), and one to the status of *Trichechus senegalensis* in Gambia (J. Powell, USA).

In all the reports and poster displays, two basic trends were discerned in the questions of systematics, phylogeny, and evolution. One of these is analysis of variability and attempts to construct phylogenetic relationships and systems for particular taxa of various ranks based on the study of biochemical and cytological characters.

In comparison with previous congresses, there was a sharp decrease in the number of papers on karyology, cytogenetics, and systematics. It is sufficient to state that the symposium on the genetics of population structure was small (5 reports and 5 poster displays), and that there were few reports on these problems in the other symposia and working groups. Main consideration is given by investigators to the study of chromosomal polymorphism in individual groups and species using G-, C-, and NOR-staining. As a rule, the significance of chromosomal recombinations in species formation and their use in taxonomy are discussed.

It can be said that the explosion of cytogenetic studies has ended and, judging by the papers presented, there is a tendency toward the further definition of already elucidated general laws in still poorly studied groups of mammals.

The second trend in the discussion of questions of the systematics, phylogeny, and evolution of mammals is in paleontological research. The main result of the discussions can be considered a conclusion on the impossibility of constructing a phylogenetic system for the class Mammalia and its subdivisions based on any single method or single group of characters. It is necessary to develop complex studies in cytogenetics, morphology, and paleontology, and to seek solutions that irrefutably unify all these data into a single taxonomic system.

Morphological problems were not divided into a separate section or symposium and were not presented in the plenary sessions, a fact which undoubtedly impoverished the ITC. As indicated in Table 1, there were only 19 papers on morphology, which was only 2.8% of the total. Morphological papers and posters were scattered among different symposia and working groups.

A summary analysis of the ecological problems addressed in the proceedings of the congress indicated that, on an organizational level, all these problems were very uncoordinated and were not unified into a common stream of ecological problems. Ecological problems were heard in many symposia and working groups, often duplicated in different places, and the conditions for a centralized general discussion did not occur.

On the whole, the IVth International Theriological Congress was a great success, demonstrating the broad development of mammalogical research, especially in ecology, and, first of all, that connected with the solution of economically important problems. The wide international cooperation between mammalogists was very useful for promoting the exchange of information on successes achieved and on perspectives. It is quite obvious that the research of Soviet mammalogists in the field of ecology is, in its level of development and breadth of interests, in no way inferior to that of the developed capitalist countries. It seems to us that, from an organizational aspect, it would be useful at subsequent congresses to reestablish the work of the sections, as the clearest form of information on the development of particular theoretical and applied trends in general mammology.

It is expedient to expand Soviet research on biological indication (with the creation of a center for bioindication, the conducting of bioindication research in biological reserves, and the training of specialists in bioindication), on the chemical communication of mammals (especially of economically important species), and on the ecological morphology and physiological ecology of mammals, and to continue intensive research on the population structure of mammals.

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