MOOSE RESEARCH AND SOCIOBIOLOGICAL MANAGEMENT

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Abstract: In view of the urgent need to modernize moose management on sociobiological principles (i.e. towards social welfare), I outline a series of top-priority research projects. Research findngs will provide moose managers with reliable indicators of population welfare and sociobiological trends. To guarantee validity of these indicators, 3 main objectives should be the basis of any new moose research: (1) the standardization of ecological, morphological, physiological and behavioural methods, (2) control of field data through simulated conditions with confined moose, and (3) a detailed inventory of moose umwelt-parameters. The essential questions concern: maturation processes, sexual behaviour, reproductive capacity of each sex, extrinsic control of populaton behaviour, growth, individual fitness, circadian periodicity, neurohormonal mechanisms, immunobiological defences, antlerogenesis and taxonomy.

At the first North American Moose Conference and Workshop held in St. Paul, Minnesota in 1963, the largest part of the "Moose Management Report" was an outline for future research. At the time, it was a good outline of what was needed. Many of the studies proposed have been done

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and others are in progress. New projects have started, stimulated by progress in field research.

It would be interesting to know how many dollars were spent on these studies: it must have been substantial. I hope that the results, by their incorporation into management procedure, have justified that investment and have contributed to the well-being of moose. However, I fear that has not been the case. Was it due to failure of the research that the results were not used by management, or was it that the results have not penetrated the sensory barriers of bureaucratic administrators? I fear the latter is the primary reason. I observe that those responsible for approving new departures in management are too far removed from today's world of the hunter and the biologist. If they had any field experience, it was long ago. Their training in bureaucracy says "Don't rock the boat." They prefer to stick with old strategies until public outcry forces a change; then they will generally present their political masters with a series of options, secure in the knowledge that politicians also prefer to stay with the status quo. In this way, the "vox populi, vox dei" is manipulated, and innovations coming from research are overlooked.

We biologists are not blameless. How many of us fear contact with press and public, or worse, dismiss such contacts as a waste of time because the complex ideas are often distorted or misunderstood. Also, our bosses are wary of too much public contact because we may support a revolutionary cause. My 30 years experience in game research and management have taught me to rely more on hunters and antihunters to spearhead my ideas, results and proposals, than on government officials. We must communicate our ideas effectively. New programs are built from the earth to the sky, not from the sky to the ground. Politicians respond to

pressure from the public, not the public servant. Bureaucrats know they are only followers, despite their occasional pretentions. New ideas cannot make it by the bureaucratic route.

However, if researchers follow the route I recommended, they must take care to maintain credibility. The first step, of paramount importance, is to choose projects carefully. They must avoid moose research whose aims, while scientifically valid, are not readily related to problems perceived by the public. Our targets must be goals of imminent concern, but at the same time, we must broaden our background in sociobiology so that our results will be conclusive, or at the very least, persuasive. Many of the best ideas in moose research today cannot be applied in management because too much general background is missing.

We must remember moose are social beings, dependent on interactions with various classes of other moose before their full neuro-endocrine potential can be expressed. Population status or personal status under simulated conditions can dramatically change many morpho-physiological, immunobiological and behavioural responses.

We need, as first priority, background studies, to tell us what a "normal" moose is. Without a baseline, we cannot recognize biased or aberrant observations. Baselines must be remembered when we are designing new projects. In the general area of sociobiology, the following areas must be studied: population density and social structure, habitat and

umwelt[1] parameters, climatic and seasonal factors, and physical and physiological condition of moose, including information on antler cycle and behaviour. If the animals are in captivity, we must further know about size and layout of the pen, social information (single animal or group, group composition, rank order), and feeding conditions. Time schedules for blood samplings must be standardized in cases of only one bleeding daily. In behavioural and immunobiological studies, the weakening or inhibitory effects of social distress on the reticuloendothelium must be avoided or a simultaneous field study with tagged individuals must be performed.

In energetic studies the metabolic norm must be maintained. This concerns the physical and chemical composition of natural food, and the possible amount of nutrients available according to age, sex, and season. Thermal and behavioural fitness of the moose and corresponding availability of nutrients are essential prerequisites in order to avoid biassed conclusions when critical conditions are under study.

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[1] Umwelt (translated from German means the "world around") as elaborated by Uexkuhl (1937), Frederichs (1950, 1951), Bubenik (1982) and others, is the complex of all environmental components (abiotic and biotic) to which the sensory apparatus and humoral mechanisms of the speces concerned respond. Hence this responsiveness is dependent on sensory threshold, which changes during maturation and might be sexually different. The umwelt-preference can change during the life cycle and seasons. Since the umwelt parameters (if known) can be quantified, the umwelt concept is suitable to manipulating the home range to its optimum or predict its suitability. In general, in one environment of a specific ecosystem there could be (at least) as many umwelts as species living there (Fig. 1).

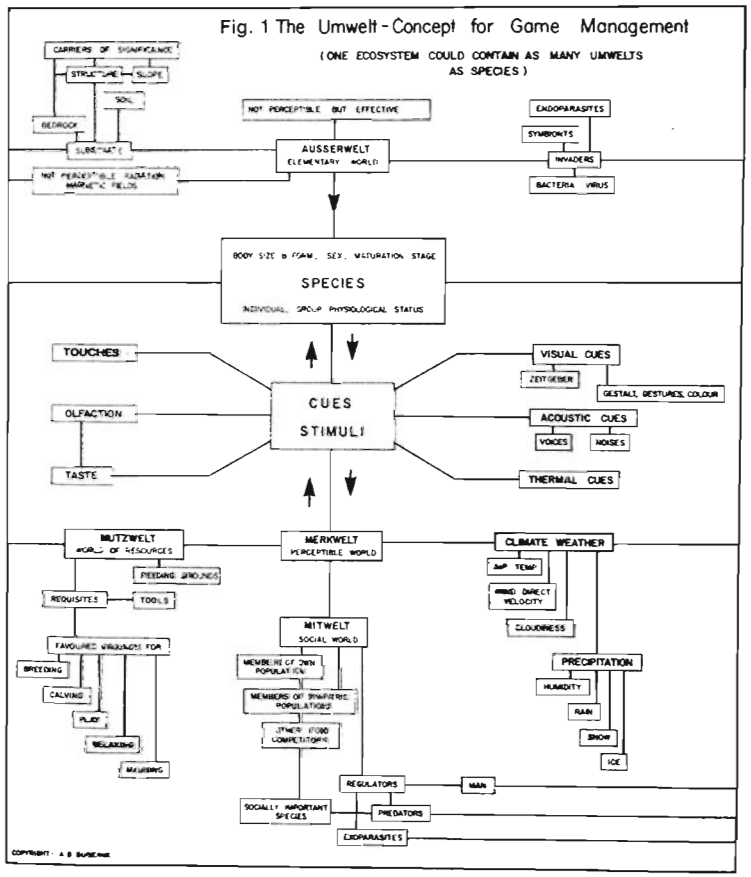

Fig. 1 The Umwelt-Concept for Game Management
(ONE ECOSYSTEM COULD CONTAIN AS MANY UMWELTS AS SPECIES)

In ecological studies, distinguish between habitat and umwelt descriptions or records. Umwelt parameters should be quantified as well as described. The complexity of umwelt relationships requires the cooperation of experts. Scholars must not forget that intra- and interspecific relationships are as important as any other ecological factors. To understand the depth of other projects, a standardized ecological form for recording background information is as essential here, as in behavioural and physiological studies.

The projects themselves must be aimed toward the benefit of moose -- not man. This is the only way for man to ensure his own benifits from moose.

Moose management must focus primarily on the well-being of populations. Only at this level of management can effective control of population structure, social balance, and optimum umwelt be obtained. Optimum population status requires permanent control of demography and density in relation to umwelt reponses and the achievement of umwelt restoration. Therefore, foresters and hunters must be involved in many moose projects. We must persuade the forester to consider the moose when choosing techniques for forest management. Forest communities which co-evolved with moose are also moose dependent. In the same way, we must convince the hunter that he must hunt moose because the welfare of moose is dependent on extrinsic control (i.e. removal of those individuals which are supernumerary) for social well-being of those who survive, and/or for umwelt conservation. This requires sophisticated culling of the population and transforms the hunter into an effective and inexpensive moose controller. This, in my view, is also the best way to salvage the hunter's future and secure him an acknowledged niche in present and future society.

I am the oldest amongst my peers, and my only ambition is to bring back the North American moose to a status of optimum well-being. Therefore, I took the liberty, on the basis of my 30 years of experience, to determine what we know and do not know about moose (not only in terms of raising their numbers, but their quality as well). This is of course personal and certainly not a complete review of questions or projects, and it is up to you how you accept and understand these ideas.

WHAT DOES MANAGEMENT NEED TO IMPLEMENT SOCIOBIOLOGICAL CONTROL OF MOOSE WELL-BEING?

To implement sociobiological management of moose we need more information in the following 9 areas:

1. One of the most pertinent questions to be answered concerns the maturation process. Knowledge of maturation allows the assessment of the population status and trends that are dependent upon synchronous or asynchronous maturation of physical, physiological and behavioural development. This in turn signals social order or disorder.

We must understand the transition from infant to teen, prime and post prime periods to estimate the demographic structure from living and harvested moose. The important point here is the age at which both sexes become prime (i.e. physically, physiologically and behaviourally mature). Moose is the largest cervid and has an astonishingly fast growth rate. As a member of the subfamily Neocervinae they complete tooth replacement about 10 months earlier than Old World deer. Does this mean that they also mature one year earlier (i.e. at 3 1/2 or 4 1/2 years)? In order to give the correct answer, we need very detailed histological, histochemical and

neuroendocrine studies of testicular and ovarian activity in non-stressed and distressed moose.

A. To understand the maturation of bulls, we must:

(1). Pay special attention to the fertilization capacity and the role of sex-hormones in the reproductive behaviour of males. This raises a number of unanswered questions concerning bulls.

(2). Determine what viable sperm volume a bull stores as he sexually matures (i.e. teen, prime and postprime age)? To answer this properly we must know what period is required for sperm to mature and how long it survives in the epididymis, and what ejaculation rate will empty the reserve, as well as what time is required to replenish this amount of viable sperm.

(3). Gain information on sex hormone secretion in bulls, as far as it concerns:

(a) what is the circannual and circadian pattern of testosterone secretion in normal and sexually hypo- and hyperstimulated bulls?

(b) which weather and behavioural factors stimulate or inhibit testosterone secretion?

(c) what is the testosterone level necessary for the induction of pedicles, antler growth, velvet shedding and antler cast?

(d) how do estrogen levels control sexual behaviour of the bull?

(e) when and what percentage of bulls have such a level as to be considered as experienced breeders, and are therefore selected by cows?

(f) do visual, acoustic, and olfactory cues of other bulls and/or cows stimulate testosterone secretion and its aromatization into estrogen, or is this process simply intrinsically controlled?

(g) does sexual hyperstimulation from childhood influence the span of the prime age of the bull and his antlerogenesis?

(h) which skin areas of bulls have testosterone receptors and which testosterone levels are necessary to initiate secondary pigmentation of head and scrotal hair?

(i) what period is required until visible darkening of hairs can be recorded?

(j) how long can the sperm survive in the fallopian tubes?

B. Similar questions arise concerning the maturation of cows.

(1). In order to estimate their maturation status and breeding potential, we must know more about the following:

(a) ovarian activity in relation to silent and overt estrus, and pheromonal secretion.

(b) does silent heat serve as a pheromonal stimulant for other cows and if so, how does this mechanism operate in woodland moose?

(c) in the case of silent heats, are all ova viable and is there any dependency on intrinsic or extrinsic factors?

(d) the number and frequency of estrous cycles in the case of failed fertilization.

(e) the number of successive pregnancies until a breakdown occurs.

(f) does milk secretion decline with age and if so, at what age? Is this an indication of the transition to post-prime status?

(g) what volume of milk can a cow moose produce during the first two months of lactation? Is the amount of milk and the milk quality dependent on age, body size, and food?

(h) How will a delay in pregnancy or lactation influence the fitness of the next calf.

(2). Concerning the cow and her behaviour we need to know:

(a) does precocious pregnancy stop the growth of the cow?

(b) what is the androgen level necessary for releasing a complete pattern of sexual behaviour in the cow?

(c) do primiparous cows develop a complete maternal pattern, or does this require at least two pregnancies?

(d) does a cow moose select among bulls, and if so, what cues are used?

C. In order to simulate natural population size, structure, and social order, we must also know more about:

(1). The growth rate and life expectancy under both well-organized and disorganized population structures.

(2). The impact on the demographic structure of a population of generations born with a majority of large or small brain case volumes.

(3). Can we estimate the absolute age of the foetus and calf in order to know the dates of conception and birth in spite of the differences of weight of newborns?

(4). Do parents which breed at a precocious age produce less viable calves?

D. In order to perform a reliable demographic inventory and cull supernumeraries, we need more information about maturation indicators, as follows:

(1). Does allometric growth of skeletal parts, and muscle development change the moose's gestalt enough that these could be used as reliable cues for normal or impaired growth and maturation classes?

(2). What is the period during which a moose skull grows?

(3). Is the volume of the brain case a reliable indicator of the

mother's age and body size, and/or her fitness during pregnancy and lactation?

(4). Does braincase volume correlate with the I.Q. and immunobiological resistence and life expectancy?

(5). Does the brain case volume correlate with body size?

E. I also stress that knowledge of antlerogenesis is not adequate to use antlers and antler cycle as indicators of population status. Therefore we must learn:

(1). Is there a tolerable minimum antler size in relation to maturation stage, physical fitness and behavioural status?

(2). What percentage of first antlers without coronet in yearling bulls will indicate that a generation is growing under conditions of distress?

(3). Does the timing schedule of antler cast in moose change with maturation?

(4). Does delayed antler cast indicate prolonged testosterone secretion?

(5). Is asynchronous antler cast typical for moose of any age or particular class, or it is an effect of distress?

2. Other objectives where our knowledge is not adequate are the indicators of the physical fitness in the autumn and later in the winter. The most paramount are:

(a) when the underfur begins to develop and what density is necessary for a good insulating layer?

(b) is the density of the underfur dependent upon age, sex, pregnancy and/or summer food?

(c) is melting snow on a moose's back a reliable indicator of poor

underfur development?

(d) how does the thickness of subcutaneous fat on the back in October, relate to fitness prior to winter?

(e) what fat reserves and underfur density do active rutting bulls have in November if the rut is 4, 8 or 10 weeks long?

(f) how much fat reserves do calves, teens and prime moose have in April?

3. Another field of importance which seems to be neglected, and for which no references are available, concerns the problem of how moose cope with parasites and disease. We have only vague ideas concerning this question. There appear to be no studies on the immune system of moose. Artificial infestations of penned moose have not been studied from this aspect. In hand reared moose there is a high probability that these invasions will proceed more quickly due to stress and may not reflect conditions in healthy animals. This might be the "weak" point of all parasitological studies "under controlled" (i.e. penned) conditions, as long as we do not know the immunobiological "norm" and do not study how moose (in both sexes and in different states of maturation) respond to different stressors. In my view we need to know:

(a) If moose are born with differing immunobiological resistences. This might be the case in calves from undernourished foetuses, calves raised on inadequate milk supplies, or in orphans. A relationship of immunobiological resistence to small-brain case volume may then be expected.

(b) If certain stressors such as physical exhaustion due to a prolonged rutting period, starvation, or general excitement from permanent harassment, weaken immunobiological defence

mechanisms.

(c) If immunobiological defences differ for populations under social distress and social well-being. Possibly heavy infestations by ecto- and endoparasites, arthritis, and paradentosis are directly related to the social status of the population.

4. From an ecological point of view, it is absolutely necessary to know the umwelt parameters of moose. We do not know much about these for woodland, lowland, mountain, or tundra moose. I would assume that there will be different parameters for each sex and perhaps each social class, at least for some periods of the year.

5. We absolutely need to know the parameters of the merkwelt, nutzwelt and mitwelt of moose. Merkwelt (from "merken" meaning perceive) encompasses environmental cues to which the animal responds. Nutzwelt (from "nutzen" meaning utilize) represents resources of the animal's umwelt. Therefore resources outside of umwelt are neglected. Mitwelt (from "to be with") represents the social world of the animal (Table 1). As long as we cannot qualify and quantify the parameters, we cannot cope, in earnest, with the so-called habitat destruction going on, and we cannot perform comparable habitat studies.

6. As far as it concerns the social umwelt of moose, a special concern, should be the "social triangle", as I call it. That is the relationships among moose, wolf and beaver, and the impact of the beaver density on wolf predation on moose.

7. Circadian periodicity is an essential area of study. Knowledge of circadian activity will improve the recording of field data and give a solid basis for simulated studies in penned moose through maintenance of

the species specific schedule of behavioural activity.

8. In order to know the "basic pattern" of circadian periodicity, I always rely on direct visual recording of penned animals not affected by unknown disturbances, and then used sophisticated telemetry recordings in order to determine if or when the basic pattern of actvity is maintained, and if the population with distorted circadian periodicity provide a different performance and behavioural pattern. This allows us to discover:

(a) what kind of circadian activity moose of different social classes exhibit from month to month,

(b) what is the frequency and duration of different behavioural periods,

(c) how physiological changes influence the basic pattern of circadian activity, and

(d) which umwelt elements can cope with the zeitgeber light-darkness as dominant synchronizer.

9. Finally, I plead for reconsideration of moose taxonomy on this continent. The taxonomic classification was done partly on skulls and antlers, without considering that the skull probably grows for 9 years and antler size and shape are the least reliable taxon. We should determine if:

(a) a short skull is inherited or merely reflects inhibited growth. Only then can we consider skull parameters as taxonomically reliable. This is not an easy task because large numbers of animals 10 years and older must be measured . Simultaneously, the growth of calves of the same subspecies must be studied under optimal conditions.

(b) the use of iso-enzymes will provide much faster insight into

population differences and taxonomy in general.

(c) it is necessary to know if the two colouration patterns, the black or dark moose and the pale moose, are genetically different.

(d) at the population level, social barriers among moose populations do exist. There could be different allo- and pheromonal components, dialects and colouration patterns. Should some of those barriers exist, then it would be easier to design management units as home ranges of populations and thereby provide more effective sociobiological moose management.

CONCLUSIONS

If we can obtain good information concerning all or most of these indicators, we can offer the manager tools to determine from harvested animals if there should be changes in the harvesting system to restore a population balance. This will provide a means of allowing population growth or reduction without disrupting the optimum social structure.

A state of population well-being is indicated by synchronous maturation processes. Based on physical, physiological and behavioural parameters from our Achental studies, at least 85% of all animals should be within their age related classes. (Bubenik, unpubl. data). Any statistically significant acceleration or deceleration of these parameters indicates changes in population behaviour. For example, accelerated sexual maturation with delayed antler cast, deteriorated energetic reserves, along with a long breeding season and high postnatal mortality, generally indicate too many cows in relation to the number of bulls, and mainly, too many teen bulls. Deceleration of maturation processes could reflect malnutrition or an overaged population. More accurate estimates could be

obtained from blood and endocrine analyses, and umwelt responses, as has been seen in red deer (Cervus elaphus and chamois (Rupicapra rupicapra).

In view of our inaccurate census and inventory methods, managing moose for optimum well-being is easier on the basis of sociobiological population trends than on this unreliable census data.

The use of morpho-physiological and behavioural indicators of population status can be done only by biologists and will justify their position. Management for numbers, to produce targets for hunters, does not need any great knowledge of moose sociobiology and can be done, as now, by moose bureaucrats, and that should not be the future of moose management in Canada or the U.S.A.

Any of the above topics is of importance. Therefore I did not select a rank order for them. I would leave it to the researchers to choose which one should be studied first. The preference depends also on such factors as field of interest, working conditions, facilities, and last but not least, the funds available. My other reason is that establishing a rank of priority would interfer with academic freedom. I can only hope that this paper will not be considered in that way.

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