Habitat Disturbance and Cardiovascular Disease in Animal Populations, with Especial Reference to the African Elephant[1]

By Sylvia K. Sikes

Eingang des Ms. 30. 9. 1967

Abstract

The African elephant was found, during a recent survey of 68 species of free-living wild mammals and birds in East Africa[2], to be susceptible to *medial sclerosis* and *"elephant atheroma"*. A pilot field study was then carried out on the ecology of these diseases in the elephant, by comparing their incidence in a 'natural' (or 'undisturbed') habitat with that in two 'degenerate' ('disturbed' or 'stressed') habitats. A correlation was found between the occurrence of these diseases and the progressive degeneration of the habitat. This in turn was associated with overcrowding and partial restriction of movement, preventing normal seasonal behaviour patterns of migration and breeding, characteristic of the species. Possible contributary factors, associated with progressive imbalance of the ecosystem, are discussed. These include sun stress, overpopulation, and dietary changes.

Introduction

A field survey of cardiovascular disease in 68 species of free-living wild mammals and birds was recently carried out in East Africa by the author under the auspices of the Nuffield Institute of Comparative Medicine, Zoological Society of London. Its primary object was to investigate the susceptibility to cardiovascular disease of animals living in natural, as compared with captive, conditions (Fiennes 1965).

Of the 43 species of mammals studied, 37 species had uncomplicated lipid deposits in the arterial intima, thought to represent a normal physiological occurrence, and 13 had atheroma-like lesions of the intima; 20 out of the 25 species of birds examined showed positive lipidosis. In some species, *medial sclerosis* and various parasitic arteritides were also found.

The African elephant *(Loxodonta africana africana* Blumenbach) was chosen from among the susceptible mammalian species as the subject of an ecological study of its naturally occurring patterns of cardiovascular disease. All subsequent references in this paper to "elephant" refer only to the African elephant, unless otherwise stated. The study was made on wild elephant living in three different habitat types: one "natural", or "undisturbed" which served as the control) and two "disturbed" or "stressed" (Fiennes 1964).

Medial sclerosis occurred in elephant, but was found to be confined to those living in the disturbed habitats

It usually affected the muscular portion of the aorta (see Fig. 2, portions III —

[1] The full manuscript of this paper, which was read at the Symposium of the Royal Society of Medicine (Section of Comparative Medicine), London, on 19th April 1967, is offered to the Zeitschrift fuer Saeugetierkunde by courtesy and recommendation of the Royal Society of Medicine, whose journal relates primarily to matters directly related to human medicine. The Royal Society of Medicine will, however, publish an abstract of this paper in their Proceedings in the near future.

[2] Financed by the British Heart Foundation.

V inclusive) and larger muscular arteries, and was characterised by the formation of rigid calcific plates in the *tunica media*, causing both rigidity and reduction in the diameter of the lumen of the artery.

Uncomplicated deposits of sudanophilic lipid could be detected in the *tunica intima* overlying the supportive structures of the aorta and the muscular arteries (including the coronary arteries) of elephants from all types of habitat. These deposits were greatest in very young calves of both sexes, and in lactating and pregnant females and were thought to be stages in a normal, possibly reversible, physiological process. These are therefore *not* treated here as "atheroma".

In elephants living in the disturbed habitats, however, additional and more extensive deposits of sudanophilic lipid were found to occur in the intima of the aorta and muscular arteries. These deposits were characteristically associated with intimal hyperplasia, disruption of the internal elastic lamina, and hyaline degeneration. In many cases they bore a considerable resemblance to lesions characteristic of human atheroma. This condition is therefore regarded as pathological and is subsequently referred to here as "elephant atheroma".

Methods

Having established the susceptibility of wild, free-living African elephants to cardiovascular disease, the next step was to determine whether there was or was not a direct relationship between the occurrence and the habitat type in which the elephants were living. Secondly, it was necessary to try to determine whether the calcific lesions seen in the *tunica media* had, or had not, got a separate aetiology from the lipid-containing intimal lesions, or "elephant atheroma". Thirdly, the nature of the apparently normal occurrence of intimal lipid deposits in all elephants, confined to certain parts of the arterial wall, also demanded further investigation, perhaps on a comparative basis, by consideration of similar occurrences in other species having same specialised adaptation of the circulatory system relative to their environment.

1. The first aspect of the problem was therefore tackled by devising simple quantitative techniques for estimating separately the relative amount of calcific deposits, and the relative amount of sudanophilic lipid laid down in the aorta[3] wall of each elephant. In each case the result was expressed as the area *per centum* of aortic wall containing the deposit. The mean percentage for each age group belonging to each habitat was then calculated.

The results in the case of aortic calcium are shown in Fig. 2. The complete absence of medial calcific deposits in elephants of all age groups living in the *montane* habitat indicates the norm. In the case of *scrubland* elephants, peak medial calcification of the aorta occured in adult elephants at about 25—30 years, (as a rough guide, it is reasonable to treat the development and life span of the African elephant as broadly comparable to that of man [Sikes 1966 a]), falling off above this point. This period coincides approximately with the onset of encroachment on the forest refuges by human settlement, and the attraction of resident elephant populations into the savannah habitats by the provision of artificial water supplies. There is therefore some reason to think that the onset of medial sclerosis in these elephant populations may have coincided with very early stages in habitats stress. In the case of the *grassland* elephants, where all adults showed some medial sclerosis, there was a sharp continuous rise into the older age groups with no clear peak. Degeneration of this habitat is more advanced

[3] In elephants, the word "aorta" here refers only to the part of the vessel distal to a transverse line running through the scar of the *ductus arteriosus* and separating the aorta from the aortic arch.

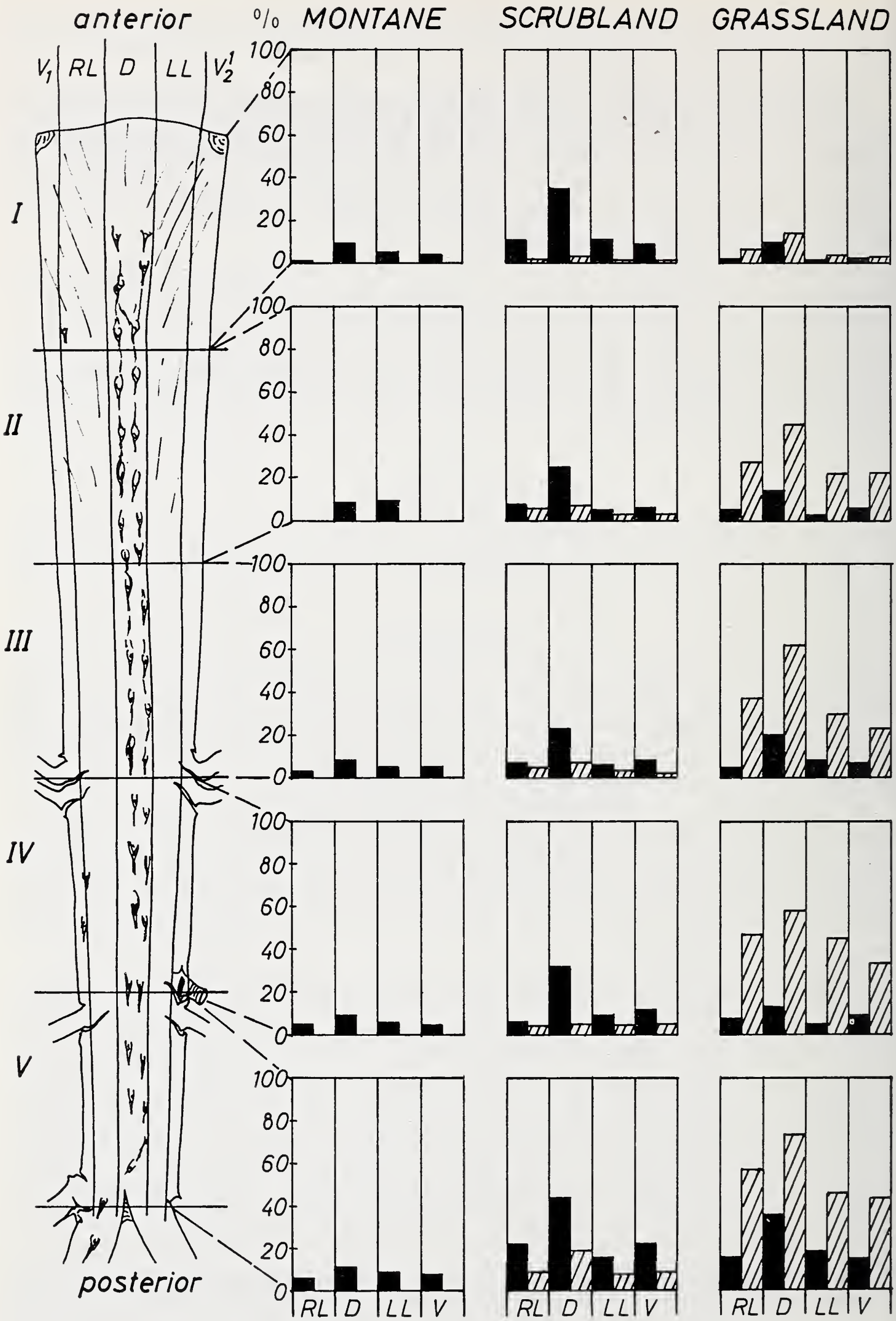


Fig. 1. Intra-Aortic Lipid/Ca, Distribution %: African Elephant: internal view of aorta wall and histograms for each portion V_1 and V_2: ventral, RL: right lateral, D: dorsal, LL: left lateral

at the time of writing (1967) than that of the scrubland type studied and probably began before any of the elephants living there today were born.

2. Secondly, the intra-aortic distribution of each was analysed by a quantitative mapping technique, based on area counts using a $^1/_2$ cm grid. The aorta was slit open by a longitudinal, ventral incision and mounted flat, intimal surface uppermost, in convenient lengths, in linear order on stiff polythene boards. The reassembled aorta was then apportioned as shown in Fig. 1, and the area counts made separately for the sudanophilic and calcium deposits in each portion. The area percentage was found in each case, and the results analysed by various methods. In Fig. 1, the extent of the sudanophilic deposits (black) and calcium deposits (shaded) in each portion of the aorta is illustrated by means of histograms. Here the mean area *per centum* of each portion of aorta containing the deposit is shown for elephants of all age groups and both sexes for each of the three habitat types studied. A summary of the mean percentage intraaortic distribution of lipoidal and calcific deposits is given in Table 1.

3. The third aspect, namely the occurrence of apparently normal deposits of intimal sudanophilic lipids in the arteries was investigated by light microscopy in conjunction with the quantitative analyses described above.

Habitat Types

The three habitat types studied will be referred to here conveniently as "montane", "scrubland" and "grassland". They were characterised by the following main features:

1. *Montane.* Extensive ranges of high altitude terrain (5,000 t 10,000 feet above sea level), indigenous, humid, alpine forest (or jungle) and moorland, cool equable temperatures, abundant flowing streams of fresh, clear water, an abundant and varied diet, including numerous kinds of arboreal fodder (fruit, foliage, twigs, bark, root and stem tubers, and leaf mould, as well as montane bamboo, sedge and other grasses). Adequate privacy and security for mating and calving, and freedom both to migrate and to meander according to the natural seasonal cycles, characterised the habitat.

This type of habitat may be regarded as "natural" and is known to have been the preferred stable environment of the African elephant in the past. There is even a hint to be detected in the illustrations on the tomb of Queen Hatshepsut at El-deir el Bahri, dating from about, 1,500 B. C., that real jungle was the type of country from which the ivory imported from the land of Pwnt (East Africa) was then obtained (Reusch 1954). As in the past, elephants living today in this habitat type are still subjected only to irregular disturbance by hunters, and are not yet overpopulated within the available range.

2. *Scrubland* and 3. *Grassland:* Both these habitat types, ecologically regarded nowadays as degenerate Savannah woodland, are unsuited in character to the continuous presence of large populations of elephant. In the past they were only used in transit during long-distance elephant migration, and, during rainy-season meanderings, for limited periods (Sikes, 1966b; Bere, 1966).

Nowadays, however, large elephant populations have become effectively confined within these areas, which usually consist of national parks and game reserves, surrounded by continually encroaching areas of human settlement with their agricultural and industrial development schemes. Total protection from hunters, and the effective closure of the old migration routes giving access to the forests, has resulted in a rapid build-up of the elephant population within the area with its sequelae of changed patterns of mating and breeding behaviour, the adoption of new food preferences, lack of exercise, changed community structure and perhaps even "boredom".

The stability of elephant communities is complex and seems to be important to their life and health. Moreover, the pressure of so many large mammals on the soil, vegetation, and water supplies has brought about an unprecedented change in the habitat itself, so that the already limited arboreal browse has had to be virtually replaced by a diet consisting mainly of grass (Buss 1961), and the essential shade canopy provided by forest thickets has virtually disappeared (Sikes, in press). These two disturbed habitats differ from each other in relation to their basic biological carrying capacity, which in turn depends upon climatic, hydrological and geological differences.

Contrary to popular concepts about these habitats (Sheldrick 1966), comparable habitats have been demonstrated in South Africa to tend, under bad management or livestock pressure, to degenerate ecologically all too rapidly, and almost irreversibly, into desert (Acocks 1964). The sensitivity of certain African habitats to overstocking was also outlined by Phillips (1959). These habitats may thus be regarded as "disturbed", "degenerate", or "stressed", insofar as these terms describe an acute imbalance of the ecosystem, in which the elephant itself figures as a major factor.

Results

The results of the quantitative investigation of the three aspects of a possible relationship between habitat type and cardiovascular disease were as follows:

1. Calcific deposits in the *tunica media* of the aorta wall did not occur in any elephant in the montane (natural) habitat. They were found in small amounts in some elephant in the scrubland habitat, especially in nursing females, sub-adults (teenagers), and prime adults (Sikes, 1966 a). They occurred in all the elephant of both sexes and all age groups examined in the grassland habitat; in some cases the condition was so advanced that the abdominal aorta resembled a rigid pipe with the lumen acutely reduced in diameter, and some of the ostia of the smaller branches totally occluded. The deposits were always maximal at the posterior end of the aorta and minimal at the anterior end, and in advanced cases, calcific deposits also occurred in variable amounts in the media of the coronary, carotid, brachial, common iliac, mesenteric, coeliac, renal and femoral arteries.

This condition was invariably associated with large, rather square-shaped, flaccid hearts with the secound (right) ventricular apex prominent, the fatty mantle reduced, and fenestrated aortic valve cusps. By contrast, in montane elephants the hearts showed high muscle tonus and an extensive fatty mantle, and had only a single ventricular apex (the left) prominent. No case of fenestration of the cusps of the aortic valve was noted in montane elephants.

2. Uncomplicated, sudanophilic lipid deposits occurred in limited amounts, confined to the intima overlying supportive thickenings of the aorta and muscular arteries (including coronaries) in all the elephants examined, including calves. These deposits were more extensive in all lactating and pregnant females than in other females and any males.

3. Sudanophilic lipid deposits occurred in some elephantes from the disturbed habitats in larger amounts in the abnormally thickened intima of the aorta and muscular arteries (including the coronaries), complicated by such changes as disruption of the internal elastic lamina, fibrous hyperplasia, a proliferation of macrophages, and hyaline degeneration. In certain cases, these resembled various types of atheromatous 'buttons', and 'plaques', and in two cases from the grassland habitat also had associated intimal calcific deposits. This condition occurred to the greatest extent in the scrubland and to some extent in the grassland elephants.

4. Medial calcification and atheroma-like plaques sometimes occurred simultane-

Intra-Aortic Distribution of lipoidal and calcific deposits

(Mean area per cent of aortic wall)

Lipid				Calcium			
RL	D	LL	V	RL	D	LL	V
			Montane Elephants				
1.1	9.8	5.6	3.6	0	0	0	0
0.6	7.9	0.5	0	0	0	0	0
3.4	8.2	5.3	4.7	0	0	0	0
5.3	9.2	5.9	4.8	0.2	0.2	0.2	0
6.2	11.5	8.8	8.0	0	0.6	0.2	0.1
			Scrubland Elephants				
11.13	34.5	11.5	9.3	1.6	2.8	1.2	0.8
8.0	24.9	5.2	5.7	7.7	6.6	2.8	2.7
7.4	22.3	6.6	8.2	5.2	7.3	4.2	2.0
6.3	27.0	9.0	11.6	4.1	5.0	3.8	5.1
22.2	44.2	15.4	22.6	9.2	18.9	8.2	8.7
			Grassland Elephants				
2.2	10.0	1.6	2.7	6.5	14.0	4.2	3.1
5.3	14.0	2.1	5.3	27.1	44.2	21.5	21.8
5.1	19.7	7.8	6.6	36.5	61.4	29.9	23.5
7.7	13.5	4.8	8.8	44.8	58.2	45.1	33.0
15.7	36.0	18.2	15.4	57.5	73.0	46.1	44.0

ously, so the intra-aortic distribution of each was analysed by means of histograms. The results showed that the development patterns were basically independent of each other. It was therefore decided to treat the two conditions separately.

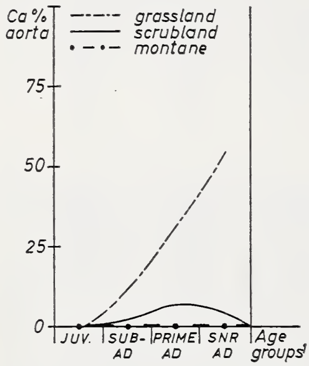
5. The calcific deposits in the arterial *tunica media* do not appear to differ histologically from those found in medial sclerosis in other mammals (Lindsay and Chaikoff, 1963) and in man. They are therefore referred to here as *medial sclerosis*. The abnormal lipid deposits had so many features resembling conditions described as "atheroma" in other mammals (Dahme, 1962; Finlayson, 1965; Gresham and Howard, 1963) that they are described here as "*elephant atheroma*". In elephant, although neither condition showed a direct correlation with age, it was apparent that in positive cases deposition of both calcium and lipid probably increases progressively in the life of the individual animal.

6. A preliminary study of the anatomy of the supportive structures in the arterial wall of a number of wild mammals (notably of the elephant, hippopotamus, rhinoceros, giraffe, eland, klipspringer, gerenuk, lion and zebra [Sikes, 1968]) suggested that in large mammals these structures have various forms according to their position in the artery relative to its branches and bifurcations. They appear also to be adapted to meet mechanical stresses operating in or on the artery by the blood itself, by movements of associated structure, and by movements of the whole animal.

It was in the intima overlying these structures that small, uncomplicated deposits of sudanophilic lipid were found to occur almost universally. It seems not improbable that such deposits represent stages in a normal, perhaps reversible physiological process. Moreover, there is some evidence suggesting that the supportive structures of the arterial wall may have specific adaptations to meet particular circulatory requirements in mammals with specialised habits, such as the amphibious habit of the hippo, or the rupicolous habit of the klipspringer.

Factors in the Disturbed Habitat which may be related to Cardiovascular Disease

It was not possible, in the study described above, to isolate specific habitat factors for analytical study in relation to the cardiovascular disease patterns found. It would be very difficult to do this in the field, other than by extensive statistical programming, and in the case of elephant this kind of study still presents almost insuperable problems in terms of available finance. The isolation of specimens in experimental areas would itself negate the object of the study, because the animals would cease to be free-living. The kind of factors usually isolated for study in this type of ecological investigation include the substrate, water, light, temperature, atmospheric gases, nutrients, interactions with other species (including man), intra-specific reactions, fluctuation of cycles of the ecosystem as a whole, and its dynamics in terms of energy turnover and productivity (Southwood, 1966).



[1] Juveniles: birth to 10 years – sub-adults: 10 to 22 ± years – prime adults: 20 – 40 ± 5 years – senior adults: 40 ± 5 years, and above (Sikes, 1966 a)

Fig. 2. Habitat and Medial Sclerosis: African Elephant

However, it is possible to mention certain factors which appear to be important in relation to the elephant populations in the habitat types studied. In the natural, or control, habitat, elephant population size is kept in check by hunters. Interesting terrain, an extensive migratory range; an abundant and varied diet; shade and humidity provided by the forst canopy and montane mists (Spurr, 1964); and privacy for breeding and the nurture of calves, apparently characterise the habitat norm for healthy elephants.

In contrast, the "stressed" or "disturbed" habitats are characterised by a resent sharp increase of the elephant populations within comparatively limited areas, in which no check on the population — as by hunters — usually occurs. Progressive destruction of the vegetational cover has taken place, restricting the diet drastically both in variety and quantity and reducing the shady canopy. Advancing destruction of the canopy has resulted in increased exposure to the unmitigated heat and light of the tropical sun. The restricted range results in frustration of the migration instinct, together with the denial of access to forests. Enforced mating and calving on the open and denuded range subjects dams and newborn calves to stress from excessive heat, light, dehydration and predators. The natural method of herd regrouping associated with former seasonal migratory movements is disrupted and behaviour patterns changed.

Discussion

It seems very possible that medial sclerosis of the arteries may have a simple and direct relationship to sun stress. It is, however, difficult to be sure whether this is due primarily to excessive exposure to direct ultraviolet rays, or whether dietary or metabolic control factors also contribute. In the case of elephant atheroma, it is again unclear whether dietary factors are of primary importance such as, on the negative side, the lack of mineral and/or vitamin-rich arboreal products, or perhaps, on the positive side, some nutrient factor peculiar to, or excessive in, the scrubland habitat. Perhaps it would be reasonable to regard these two forms of cardiovascular disease in elephants as indicators of stress, whether the operating stress is simple or multifactorial.

In searching for possible explanations in the case of elephants, we can as yet only speculate as to what factors may really constitute "stress" to an elephant, for the study of ecology and ethology of the large African mammals is still only in its infancy. It is possible, however, to discuss some of the more obvious of the environmental factors which, in the degenerate habitats, have deviated from the norm (forest).

Light is the first of these factors. This may have particular significance in the case of a naturally migratory animal such as the African elephant. Length of day, light intensity and wave length are now known to be variables directly associated with the migratory habit in birds and certain small mammals in temperate zones. The light stimulus, incident on the eye, indirectly affects the anterior lobe of the pituitary by way of the central nervous system. The first extensive studies of this type were made by Rowan (1932; 1938), Benoit (1936) and Benoit and Ott (1944). Bisonnette and Wadlund (1932) and Riley (1936; 1937) and Miller (1948) also showed that the reproductive period, stimulated initially by the increasing length of day, in certain migratory birds is followed by a refractory period of insensitivity of these endocrine glands to changes in the light stimulus.

In migratory species of birds which cross the equator during the southward flight, stimulation of the gonad by the increased light intensity in the lower latitudes is inhibited during this refractory period. Bissonnette (1932) was also able to produce precocious maturation of the testes of ferrets which were artificially illuminated outside the normal breeding season. Delost (1960; 1962) studied the relationship between light, endocrine changes, and migration in some migratory mammals in France, namely some rodents and insectivores, and found a direct relationship between changes in the length of day, the activity of the adrenal gland, and the onset of migration. There is thus an increasing body of evidence that the normal migratory, endocrine and reproductive patterns of certain birds and mammals are largely dependent upon stimulation by light.

The disruption of these patterns by a change in the environmental light stimulus may thus cause metabolic or endocrine changes, which may, in turn, have some indirect relationship to the occurrence of cardiovascular disease. A seasonal fluctuation in lipidosis was demonstrated in rats by Thorp (1963). Perhaps experiments using a light stimulus of variably controlled intensity, wave length and exposure time, incident directly and/or indirectly on the eyes of selected wild mammals, known to have seasonal light-dependent rhythms, could be designed to investigate the problem further.

Overcrowding. The effect of enforced overcrowding in large gregarious mammals such as elephant may also be an important factor. It seems probable that it may result in disruption of intra-herd reactions and status. In the past, huge temporary congregations of several elephant herds and clans were formed during the migratory period. By contrast, elephant populations nowadays effectively confined within the disturbed habitats, are virtually stationery. There appears to be no adequate outlet for the seasonal energy build-up formerly utilised on the long migratory marches. Accounts of the apparently wanton destruction of trees by elephant in these habitats (Anon. 1957) perhaps suggest an answer. And, although it has been stated (Bere 1966) that elephants do not exhibit "territorial behaviour", there is good reason to think that they may exhibit both seasonal and spacial interactions within the herd which constitute a form of "territorial" reaction. In some cases, disruption of such behaviour patterns results in "displacement behaviour", which may take the form of a natural vandalism. This type of behaviour was noticed by Prior (1964) in roedeer in England and was discussed more recently by Ardrey (1967).

Many wild animals also require the stimulus of certain behaviour patterns involving aggression and display before effective mating can take place: in overcrowded conditions these requirements may not be fulfilled. Perhaps a combination of factors of this type, disrupting specific behavioural sequences, with an associated disruption of endocrine cycles, may contribute to changes already noted in the breeding cycle of elephants in a degenerate habitat in Uganda, described by Buss and Savidge (1966).

Dietary restriction and imbalance may also cause some imbalance of the internal environment of the body, which in turn may lead to specific metabolic derangement, such as that of calcium and lipids.

Without human interference, it is probable that natural selective processes in a wild population of elephant in an increasingly ill-balanced eco-system would begin to operate early, eliminating supernumerary animals and increasing infant mortality, until equilibrium between the animal population and its habitat was restored (Errington 1957). In the elephant populations studied by the author, however, in one such habitat the elephant had not only been protected from their main natural predator (man), but had even been provided with artificial water supplies when a severe natural drought occurred in 1961, which would otherwise have decimated the population (Sikes 1966 b). This population had thus been protected from the effective operation of two major natural selective processes.

Intrinsic selective processes, however, had apparently not been prevented, for the high incidence of advanced medial sclerosis in the habitat under maximum stress suggests that this disease may function as a natural population-control mechanism in elephant. It not only reduces the health and mobility of individual animals, but also apparently reduces overall longevity in the population as a whole (Sikes, in Press). In the partially stressed habitat, its incidence in younger animals and nursing cows, with a peak in the 25—30 years age group, suggests that it could be regarded as an indicator of the incipient breakdown of at least one important factor in an environment optimal for elephant — namely the amount and kind of incident light.

The incidence of "elephant atheroma" is more difficult to interpret in these terms, but its direct correlation with habitat degeneration suggests that it also may indicate a deviation in some other environmental factor, or factors, at present unidentified, from the optimum.

Acknowledgments

The survey, of which the studies on cardiovascular disease in African elephant described in this paper were part, was financed by the British Heart Foundation, and carried out under the auspices of the Nuffield Institute of Comparative Medicine, Zoological Society of London. The sponsorship of the project by these organisations is gratefully acknowledged.

The author is indebted to Mr. R. N. T-W-Fiennes, Pathologist, Zoological Society of London, and Professor J. F. Smith, Department of Morbid Anatomy, University of London, for advice on the identification of pathological lesions and their relationship to those of similar diseases in man. The assistance given by the Game and Parks Departments of Kenya and Uganda in authorising the collection of the elephants for autopsy is also gratefully acknowledged.

Zusammenfassung

Während einer kürzlich unternommenen Serie von Beobachtungen an 68 Gattungen von freilebenden wilden Säugetieren und Vögeln in Ost-Afrika wurde festgestellt, daß der afrikanische Elefant die Tendenz zu medialer Sklerose der Aorta sowie zu „Elefanten-Atheroma" aufweist.

Daraufhin wurde eine vergleichende Studie der Oekologie dieser Kreislauferkrankungen an Elefanten unternommen, um festzustellen, inwiefern die Inzidenz derselben beeinflußt wird von den Umständen in einem natürlichen, oder „ungestörten", Habitat im Gegensatz zu den Umständen in zwei Habitat-Typen, deren Gleichgewicht gestört, „degeneriert" oder „stressed" ist.

Das Auftreten dieser Erkrankungen zeigte einen klaren Zusammenhang mit der fortschreitenden Degeneration des Habitats. Diese wiederum war verbunden mit Überbevölkerung und teilweiser Beschränkung der Tierbewegungen, so daß das normale, dem Elefanten eigene, jahreszeitlich bedingte Verhalten in bezug auf lange Wanderungen und Fortpflanzung unterdrückt oder stark behindert war. Andere Faktoren, die zu den Erkrankungen beitragen können

und im Zusammenhang mit dem gestörten Gleichgewicht des Ekosystems stehen, wie übergroße Sonnenbestrahlung, Übervölkerung und einschneidende Änderungen in der Äsung der Elefanten, werden diskutiert.

References

Acocks, J. P. (1964): Karoo vegetation in relation to the development of deserts. Ecological Studies in Southern Africa. 100—112 (Ed. D. H. S. Davis) The Hague: Funk.

Anonymous (1957): Tsavo Royal National Park. Royal National Parks of Kenya. 33—51. Nairobi.

Ardrey, R. (1967): The Territorial Imperative. London: Collins.

Benoit, J. (1936): Facteurs externes et internes de l'activité sexuelle. 1. Stimulation par la lumière de l'activité sexuelle chez le canard et la cane domestiques. Bull. biol. Fr. Belg. **70**, 487—533.

Benoit, J., and Ott, L. (1944): External and internal factors in sexual activity. Effect of irradiation with different wave-lengths on the mechanisms of photostimulation of the hypophysis and on testicular growth in the immature duck. Yale J. Biol. Med. **17**, 24—46.

Bere, R. (1966): The African Elephant. London: A. Barker.

Bissonnette, T. H. (1932): Modification of mammalian sexual cycles; reactions of ferrets *(Plutorius vulgaris)* of both sexes to electric light added after dark in November and December. Proc. Soc. **B 110**, 322—336.

Bissonnette, T. H., and Wadlund, A. P. R. (1932): Duration of testis activity of *Sturnus vulgaris* in relation to type of illumination. J. exp. Biol. **9**, 339—350.

Buss, I. O. (1961): Some observations on food habits and behaviour of the African elephant. J. Wildl. Mgmt. **25**, 131—148.

Buss, I. O., and Savidge, J. M. (1966): Change in population number and reproduction rate of elephant in Uganda. J. Wildl. Mgmt. **30**, 791—809.

Dahme, E. (1962): Morphological changes in the vessel wall in spontaneous animal arteriosclerosis. J. Atheroscler. Res. **2**, 153—160.

Delost, P. (1960): Nutrition et cycles endocriniens chez les mammifères sauvages non-hibernants. Annls. Nutr. Aliment. **14**, 53—109.

— (1962): Seasonal endocrine cycles of wild mammals and their causes in nature in France. Proc. 1st Int. Conf. on Wildl. Dis., New York.

Errington, P. L. (1957): Of population cycles and unknowns. Cold Spring Harbor Symposium.

Fiennes, R. (1964): Man, Nature and Disease. London: Weidenfeld.

— (1965): Atherosclerosis in wild animals. In: Comparative Atherosclerosis. (Eds: J. C. Roberts and R. Straus) 113—126. New York: Harper and Row.

Finlayson, R. (1965): Spontaneous arterial disease in exotic animals. J. Zool. **147**, 239—343.

Gresham, G. A., and Howard, A. N. (1963): Comparative histopathology of the atherosclerotic lesion. J. Atheroscler. Res. **3**, 161.

Lindsay, S., and Chaikoff, I. L. (1963): Naturally occurring arteriosclerosis in animals: a comparison with experimentally induced lesions. Atherosclerosis and its Origin, 349—457. (Eds: M. Sandler and G. H. Bourne). New York: Acad. Press.

Miller, M. R. (1948): The seasonal histological changes occurring in the ovary, corpus luteum and testis of the viviparous lizard *Xantusia vigilis.* Univ. Calif. Publs. Zool. **47**, 197—223.

Phillips, J. (1959): Agriculture and Ecology in Africa. London: Faber.

Prior, R. (1965): Living with Deer. Survival Book Series No. 3. London: André Deutsch.

Reusch, R. (1954): History of East Africa. Stuttgart: Evangel. Missionsverlag.

Riley, G. M. (1936): Light regulation of sexual activity in the male sparrow *(Passer domesticus)* Proc. Soc. exp. Biol. Med. **34**, 331—332.

— (1937): Experimental studies of spermatogenesis in the house sparrow, *Passer domesticus* (Linnaeus). Anat. Rec. **67**, 327—351.

Rowan, W. (1932): Experiments in bird migration. 3. The effects of artificial light, castration and certain extracts on the autumn movements of the American crow *(Corvus brachyrhynchos).* Proc. natn. Acad. Sci. U.S.A. **18**, 639—654.

— (1938): Light and seasonal reproduction in animals. Biol. Rev. **13**, 374—402.

Sheldrick, Daphne (1966): The Orphans of Tsavo. London: Collins.

Sikes, S. K. (1966 a): The African elephant *Loxodonta africana:* a field method for the estimation of age. J. Zool. London **150**, 279—295.

— (1966 b): The African elephant: the background to its present-day ecological status in the Murchison Falls (Uganda) and Tsavo (Kenya) National Parks and environs. Rev. Zool. Bot. Afr. **74**, 255—272.

— (1968): Observations on the internal structure of the aorta in East African mammals, with

particular reference to the klipspringer, gerenuk, and hippopotamus. Z. Säugetierkunde **33**, 27—42.
— (in press): Observations on the ecology of arterial disease in the African elephant *(Loxodonta africana)* in Kenya und Uganda. Comparative Nutrition in Wild Animals (Ed: M. A. Crawford), Symp. Zool. Soc. No. **21**. London: Academic Press.
Southwood, T. R. E. (1966): Ecological Methods. London: Butler & Tanner.
Spurr, S. H. (1964): Forest Ecology. New York: Ronald Press.
Thorp, J. M. (1963): Effects of seasonal variation on lipid metabolism in animals and man. The Control of Lipid Metabolism. (Ed. J. K. Grant). London: Academic Press.

Authors address: Dr. Sylvia K. Sikes, Canadian Wildlife Service, Edmonton, Alberta, Canada

Das Selbstbespeicheln des Igels, *Erinaceus europaeus* Linné, 1758, steht in Beziehung zur Funktion des Jacobsonschen Organes

Von Walter Poduschka und Wilhelm Firbas

Aus dem Anatomischen Institut der Universität Wien – Vorstand: Prof. DDr. Heinrich Hayek

Eingang des Ms. 7. 4. 1967

Über das Selbstbespeicheln von Igeln wurde schon viel geschrieben, da diese Tätigkeit sehr bemerkenswert ist und bisher noch von keinem anderen Tier mit Ausnahme des Igeltanreks, *Echinops telfairi* (Eibl-Eibesfeldt 1965 und 1966, Gould & Eisenberg 1966) bekannt wurde. Hier soll im folgenden eine Deutung dieses Verhaltens dargelegt werden. Der eine der beiden Verfasser (Poduschka 1967) untersuchte das Verhalten von Igeln, und zwar von mittel- und osteuropäischen Angehörigen der Rasse *Erinaceus europaeus roumanicus*, ist für die entsprechenden Kapitel dieser Arbeit verantwortlich und wurde auf das Organum vomeronasale Jacobsoni aufmerksam, dessen Untersuchung beim Igel von dem anderen Verfasser durchgeführt wurde.

Problemstellung und bisherige Deutungsversuche

Jeder Igelbeobachter hat schon bemerkt, daß ein Igel nach Beschnuppern oder Bekauen von bestimmten Gegenständen, jedoch auch — was besonders hervorzuheben ist — beim Einatmen gewisser Gerüche nach einer kurzen Weile den Kopf waagerecht hält, durch kauende Bewegung der Kiefer schaumigen Speichel im Maul erzeugt und diesen dann nach kurzer Zeit an den Stacheln der Seiten, des Rückens oder des Nackens, bzw. an den Seitenhaaren — seltener an denen der Brust — mit Hilfe der Zunge absetzt. Der einmal gewählte Fleck am eigenen Körper wird während eines einzelnen Bespeichelaktes nie gewechselt, folgt jedoch ein neuerliches Einspeicheln, wird eine andere Stelle am Stachelbalg oder auf den Haaren gewählt. Im Falle des Bekauens eines Gegenstandes färbt sich der schaumige Speichel meist nach der Farbabgabe des zerkauten Objektes[1]. Eine zufriedenstellende Erklärung des merkwürdigen Vorganges ist noch nicht be-

[1] Hier gibt es indessen auch Ausnahmen. So pflegen zwei meiner Igel eine auf dem Boden meines Arbeitszimmers liegende schwarzbraune Wildschweindecke zu bekauen und sich dann mit blendendweißer Speichelmasse zu beschmieren.