Weight Variation in Adrenal Glands of the Mongoose in Hawaii

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ABSTRACT: Gross morphology and weight characteristics are described for adrenal glands in a population of the small Indian mongoose, *Herpestes auropunctatus* (Hodgson). Mongoose adrenals are anatomically similar to those in the cat and dog, and may be typical of those in the Order Carnivora. The right gland is about 80% as large as the left. Relative adrenal weight decreases in all age and sex classes as body weight increases. Adrenals are only slightly larger in young females than in young males, but at sexual maturity they enlarge greatly in females and remain much larger than those in males. In lactating females the adrenals are significantly larger than those in all other classes of adult females. There seems to be no major effect of sexual maturity on adrenal size in males. Over a three-year period the population demonstrated a remarkable stability of adrenal gland weight in the face of increasing drought and decreasing numbers. Minor adrenal response to seasonal fecundity, environmental stress, and variations in population density may be a character of carnivores quite in contrast to that observed in the highly sensitive rodents.

THERE HAVE BEEN two recent analyses of how the pituitary-adrenocortical-gonadal system effectively regulates growth and decline of free-living mammalian populations. Christian (1961) emphasizes the intrinsic mechanisms of density and social interaction as the indirect effecters of population control. Negus, Gould, and Chipman (1961) attribute this regulation primarily to the extrinsic factors of climate and nutrition. Further progress in understanding adrenal gland function as it applies to population theory depends in part on a clearer knowledge of adrenal form and size patterns as they occur in the several orders of mammals.

This report on the small Indian mongoose, *Herpestes auropunctatus* (Hodgson), increases what is known about the carnivores, which have apparently been omitted from population studies dealing with the adrenals. The mongoose was introduced into Hawaii in 1883 from stocks earlier transplanted to Jamaica from India, and it became rapidly established on four of the main islands.

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METHODS

Samples of mongoose adrenals were collected monthly in Hamakua District on Hawaii Island between April, 1960 and March, 1963 during ecological studies of the reservoirs and vectors of bubonic plague. The mongooses were trapped alive, killed with CaCN dust, taken to the laboratory and weighed. Adrenals were removed, trimmed of adherent tissue, and preserved (in 10% neutral formalin, except for a small number of those collected in the third year, which were placed in Bouin's fluid). After fixation each pair of glands was blotted on paper toweling and weighed immediately on a torsion balance to an accuracy of 0.1 mg. Weights were then expressed in milligrams per 100 grams of body weight (mg%), and are presented throughout the report in this relationship.

For statistical analysis the 36 monthly samples comprising 784 pairs of adrenals were sorted according to age, sex, and reproductive state of the individual mongoose. Age classes were two: immature and adult. Males with the bare testes less than 8 mm long were classed as immature (and hence sexually inactive), and all others were considered adult; criteria were approximately those of Pearson and Baldwin

(1953). Females were classed as immature if non-parous and inactive, and as adult if in any stage including and following first onset of uterine enlargement. Adult females were subdivided into four classes: active (preimplantation), pregnant, lactating, and inactive, in the sequence of the breeding cycle.

Analysis of variance by the approximate method of unweighted means (Snedecor, 1956: 385–386) was the principal test applied. The more sophisticated method of fitting constants (Steel and Torrie, 1960: 257–265) was used to determine levels of significance between years in the combined classes. Duncan's new multiple range test (Steel and Torrie: 107–109) extended the usefulness of both these methods.

ANATOMICAL DESCRIPTION

Mongoose adrenal glands are quite regular in shape, lacking the acutely angular borders, prominent notching, and frequently bi-lobed appearance of these glands in the dog as figured by Baker (1936). The left gland is somewhat elongate and flattened compared to the right one, which is often blunt and thick with slightly angular lateral and ventral borders. Both glands tend to narrow toward the posterior end. They lie closely against the dorsal body wall just medial to the anterior poles of the kidneys. The right gland is nearly concealed by the postcaval vein, and this seems to enhance its medio-lateral depression and to form the angular borders described. The caudate lobe of the liver envelopes the free surfaces of this gland, the lateral surface in particular, and intensifies its crowded position. The left gland is freely situated; it lies adjacent to the postcaval vein and is lightly pressed against the dorsal body wall by the pancreas and stomach.

One adrenolumbar vein courses along the anterior and dorsolateral surfaces of the right adrenal, and receives a prominent branch from its anterior quarter. The other arches across the posterior ventral third of the left adrenal, receives a branch from this gland, and frequently impresses a slight notch in its medial border where the vessel enters the left renal or the postcaval vein.

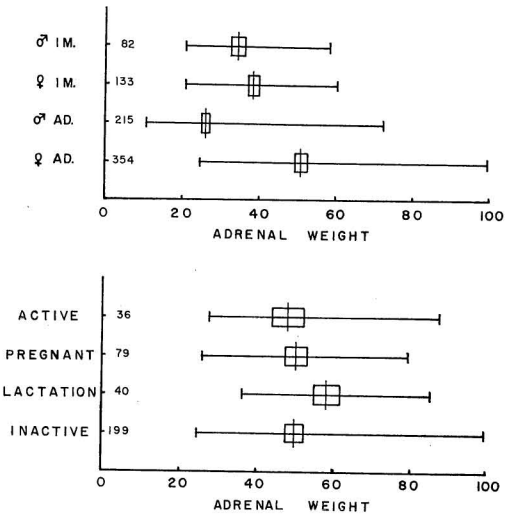

FIG. 1. Mongoose adrenal weights in milligrams per 100 grams of body weight, according to age and sex (*above*), and for the adult females classed by reproductive condition (*below*). Means plus and minus two standard errors, extremes, and sample size are indicated for each class.

The right adrenal is smaller than the left one, as in most mammals. The mean weight of the right gland in a series of 20 males was $79.3 \pm 0.53\%$ (1 SE) of the left one, and in 20 females it was $79.7 \pm 0.66\%$ ($P < 0.01$ in both sexes between right and left glands).

RESULTS

In young males (Fig. 1) the mean relative adrenal mass is slightly smaller than in young females ($P < 0.05$). In adults this divergence is intensified: for males relative mean gland size becomes even smaller, and for females it becomes much larger ($P < 0.01$ in comparisons of adults of each sex with all other classes). Seasonal fluctuations in adrenal size are small in adults. Among females (Fig. 1) significant change occurs only in lactation, when size is greater than in any other adult class ($P < 0.01$ for each). Testes of adult males regress only slightly in the non-breeding period, approximately from August through December. In a sample of 126 males older than one year, as judged by progressive toothwear, I found no significant differences in adrenal size between

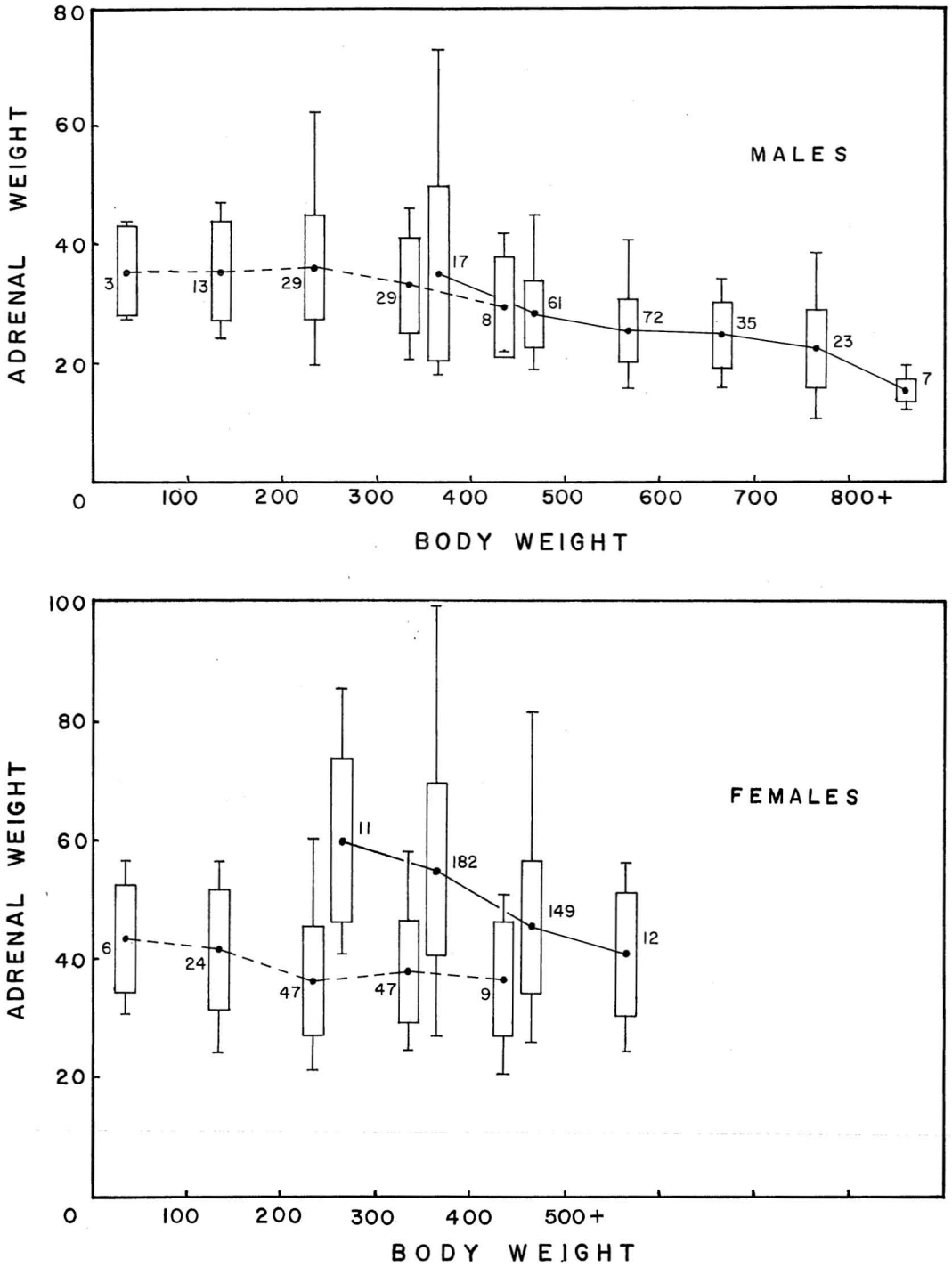

FIG. 2. Adrenal weights of mongooses in milligrams per 100 grams of body weight plotted against body weight. Means plus and minus one standard deviation, extremes, and sample size are indicated for each 100-gram class. Solid lines connect means of adult classes; dashed lines connect means of immature classes.

TABLE 1

ADRENAL SIZE (IN MG/100 G BODY WT) IN ADULT MALE MONGOOSES BY SEASON

SEASON	NUMBER	RANGE	MEAN	SE
Breeding (Jan.–July)	86	11.9–62.3	27.9	± 0.76
Nonbreeding (Aug.–Dec.)	40	14.1–52.9	25.7	± 1.73

those taken in the breeding season and those taken after it (Table 1).

As body weight of males increases there is an almost continuous trend in reduction of relative adrenal weight (Fig. 2). The transition to adulthood is smooth, showing that adrenal size is not greatly influenced by sexual maturity. In contrast, although the trend in young females matches closely that in young males, adult females demonstrate an explosive increase in adrenal size. Once this increase is established, the mean trend in its reduction as body weight increases covers almost the same amplitude as that in adult males (though distributed over four weight range classes instead of six).

In the advanced fetus, adrenal glands are noticeably large and their relative weights exceed those of all other age classes examined ($P < 0.01$). Three fetuses near term and averaging 20.1 g in body weight had a mean relative adrenal mass of 125.0 ± 11.4 mg % (1 SE).

DISCUSSION AND CONCLUSIONS

The cat (Northup and Van Liere, 1960) has a slightly larger adrenal mass in adult females than in adult males, and in smaller members of both sexes than in the larger ones. Baker (1936) examined 1250 dogs of a wide variety of breeds and ages, and found conditions in immature animals similar to those which I found in the mongoose. When body weight of dogs increased, relative adrenal weight decreased in all classes; but, as in cats, adult females had only slightly larger adrenals than did adult males. This may be related to the status of both these species as domestic animals. Among wild species the basic pattern of adrenal weight variation in the vole, *Microtus montanus* (McKeever, 1959), is similar to that in *Herpestes auropunctatus,* although in the vole prominent seasonal variation occurs as it does in most short-lived rodents, and this is not found in the mongoose.

Mongooses used in this study were collected in a period of almost continuously subnormal rainfall and increasingly serious drought conditions. The moderately dense population decreased markedly in most sections of the district (Tomich, MS). Yet no significant differences were observed in adrenal size among the three years within any of the age and sex classes (Table 2). The female reproductive stage classes were likewise remarkably uniform in the three years, and also showed no significant differences (Table 3). Statistical interaction was not evident.

This rigid stability within the various classes may be interpreted in terms of stress theory to mean that environmental and sociological effects were actually slight and easily accommodated, or that the mongoose is refractory in the nature of its pituitary-adrenocortical-gonadal system to effects commonly measureable in rodents. Fat is not a complicating factor in these relationships because few animals had fat deposits and these deposits were seldom large.

Unexpectedly, there was within each class a downward trend by years in mean adrenal values (*see* Table 2). In the first year (all classes combined) adrenals were larger than in the two succeeding years ($P < 0.01$ for each). The implication of this observation is that a normally wet year with a high population was less favorable to the mongooses than the following dry years with a reduced population. In view of the generally slight adrenal response within the various classes, I prefer to withhold judg

ment on this matter until further evidence is available.

McKeever (1959) reviewed the effects of reproductive hormones on adrenal size in mammals, stating that in general androgens decrease, and estrogens increase, thickness of the adrenal cortex, and that this results in changes in adrenal weight. These effects are suggested by data on the mongoose because of the gradual reduction of relative adrenal size in the maturing male and its sudden enlargement once the female is adult.

Histological study (McKeever and Tomich, 1963) confirms the above observations and reveals an inner zona fasciculata in adrenals of adult female *Herpestes auropunctatus* which accounts in part for the large cortical width in that class. This subzone reaches its greatest development during lactation, when cortical width and adrenal weight are at a maximum.

The implications of adrenal size patterns as they vary in the several orders of mammals are not completely elucidated by available data. At least some lagomorphs are unlike the carnivores; in both *Oryctolagus* and *Sylvilagus* adrenals of all age groups are larger in males than in females, about 40% heavier when considering all age classes together (Wodzicki and Roberts, 1960). Two species of ground squirrels (*Citellus*), whose adrenal weights are known, depart from the usual pattern in rodents and also have significantly larger adrenals in males than in females (Tomich, 1962), but in a third species (McKeever, 1963) the reverse is true. There is little evidence from behavioral observation to show why these conditions may vary so widely among closely related groups or be so similar in distantly related groups of mammals. It seems probable, nevertheless, that carnivores in general are conservative in adrenal responses measureable by the condition of these organs, when compared with the better known lagomorphs or rodents.

ACKNOWLEDGMENTS

This research was supported by the State of Hawaii Department of Health and by National Institutes of Health Grant E-2886, Charles M. Wheeler, Principal Investigator. Oliver P. Pearson and Sturgis McKeever read the manuscript and offered many useful suggestions for its improvement. Larry A. Nelson and Albert L. Tester gave their time and advice freely in the more elaborate statistical analyses.

TABLE 2

ADRENAL SIZE (IN MG/100 G BODY WT) IN THE MONGOOSE BY AGE AND SEX DURING A THREE-YEAR PERIOD

CLASS	YEAR	NUMBER	RANGE	MEAN	SE
Young males	1st	34	24.2–58.1	35.8	± 1.44
	2nd	23	21.9–53.8	35.7	± 1.81
	3rd	25	20.6–46.3	32.0	± 1.53
	all	82	20.6–58.1	34.6	± 0.92
Young females	1st	38	26.1–58.7	40.4	± 1.41
	2nd	39	24.4–56.6	39.1	± 1.37
	3rd	56	20.8–60.2	36.3	± 1.24
	all	133	20.8–60.2	38.3	± 0.78
Adult males	1st	71	10.4–72.4	27.4	± 0.92
	2nd	72	11.9–45.0	26.3	± 0.89
	3rd	72	12.8–62.3	25.6	± 0.91
	all	215	10.4–72.4	26.4	± 0.52
Adult females	1st	152	26.2–87.3	52.0	± 1.07
	2nd	84	24.6–97.5	50.5	± 1.68
	3rd	118	26.0–99.6	49.7	± 1.31
	all	354	24.6–99.6	50.9	± 0.73

TABLE 3

ADRENAL SIZE (IN MG/100 G BODY WT) IN ADULT FEMALE MONGOOSES BY REPRODUCTIVE CLASS

CLASS	YEAR	NUMBER	RANGE	MEAN	SE
Active	1st	12	41.7–87.3	56.2	± 3.66
	2nd	13	27.6–65.3	43.4	± 2.80
	3rd	11	34.2–68.6	46.5	± 3.20
	all	36	27.6–87.3	48.6	± 2.02
Pregnant	1st	42	26.2–79.0	49.9	± 1.96
	2nd	15	25.7–57.7	46.6	± 2.29
	3rd	22	37.9–71.6	53.6	± 2.23
	all	79	25.7–79.0	50.3	± 1.30
Lactating	1st	25	45.3–85.0	60.1	± 2.19
	2nd	8	36.6–73.0	53.8	± 4.24
	3rd	7	49.9–62.7	56.9	± 1.68
	all	40	36.6–85.0	58.3	± 1.68
Inactive	1st	73	26.7–85.5	49.8	± 1.23
	2nd	48	24.6–97.5	53.2	± 2.58
	3rd	78	26.0–99.6	48.4	± 1.78
	all	199	24.6–99.6	50.1	± 1.04

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