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Dama dama.

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Dama dama (Linnaeus, 1758)

Fallow Deer

Cervus dama Linnaeus, 1758:67. Type locality Sweden (introduced). Type species of *Dama* Frisch, 1775 validated by plenary powers.
Platyceros plinii Zimmerman, 1780:129. Renaming of *dama*.
Cervus platyceros G. Cuvier, 1798:160. Renaming of *dama*.
Cervus mauricus F. Cuvier, 1816:72. No locality given.
Cervus (Dama) mesopotamicus Brooke, 1875:264. Type locality Khuzistan, Luristan (Persia), Iran.

CONTEXT AND CONTENT. Order Artiodactyla, Suborder Ruminantia, Family Cervidae, Subfamily Cervinae, Tribe Cervini. The genus *Dama* is here recognized, although some authors (Honacki et al., 1982) consider it to be congeneric with *Cervus*. The generic name *Dama* for the fallow deer was validated by Opinion 581 of the International Commission on Zoological Nomenclature. Some earlier authors (Ellerman and Morrison-Scott, 1951; Lydekker, 1898) considered the Persian fallow deer (*D. d. mesopotamicus*) a separate species. Most recent authors (Corbet, 1978; Haltenorth, 1959; Harrison, 1968) gave the Persian fallow deer subspecific status, although Haltenorth (1963:56) and Ferguson et al. (1985) considered it to be a distinct species.

D. d. dama (Linnaeus, 1758:67), see above (*albus* Fitzinger, *leucaethiops* Fischer, *maura* Fischer, *mauricus* Cuvier, *niger* Fitzinger, *platyceros* Cuvier, *plinii* Zimmerman, *varius* Fitzinger, and *vulgaris* Fischer are synonyms).
D. d. mesopotamicus (Brooke, 1875:264), see above (*mesopotamiae* Trouessart, is a synonym).

DIAGNOSIS. In European fallow deer shoulder height of males is about 0.9 to 1.0 m, with females slightly smaller. Forelegs are somewhat shorter than hind legs, so the line of the back is elevated posteriorly (Fig. 1; Flerov, 1952). The "Adam's apple" is prominent in males. Pelage color is variable and spots usually are evident in all age classes.

Antlers usually are found only in males. Yearlings generally produce unbranched "spike" antlers 3 to 15 cm long. In adults, antlers are characteristically palmate in individuals 3 years of age and older. The antler beam is narrow and cylindrical, and curves laterally and posteriorly at about a 60° angle from the pedicel. An upswept, well-developed brow tine arises just above the coronet. The bay tine usually is absent. A small trez tine projects laterally just below the palm. Antler length ranges from 50 to 70 cm; the width of the palm ranges from 7 to 20 cm, and the palm is inflected medially at the top (Fig. 1). Several projections ("spellers" or "snags") are directed posteriorly, with the longest at the bottom of the palm (Cadman, 1966; Chapman and Chapman, 1975). In Persian fallow deer broad, fan-shaped palmation usually occurs basally immediately above the short brow tine. The beam extends from the posterior portion of the palm, ending in a variable number of tines (Brooke, 1875; Haltenorth, 1959; Harrison, 1968).

The skull is shorter and broader and has larger orbits than in *Cervus* (Harrison, 1968). Prelacrimal vacuities are large but shallow, the lacrimal fossa is pronounced, and two lacrimal ducts are on the rim of the orbit (Fig. 2). The vomer does not partition the internal nares. Premaxilla usually articulates with nasals. Harrison (1968: 365) noted ". . . the proximal end of the nasal bones is blunt in *D. d. mesopotamica* and their lateral profile is more strongly convex than in *D. d. dama*; the suture between the malar and superior maxilla is about equidistant from the lower border of the molars [in Persian fallow deer], in *D. d. dama* it is much nearer to the orbit." There usually are no upper canines, first pair of incisors with large, spatulate crowns, lower canines incisiform, and molariform dentition hypsodont. Dental formula is i 0/3, c 0/1, p 3/3, m 3/3 total 32. Detailed descriptions of the skull and dentition of European fallow deer are in Flerov (1952), and Harrison (1968) described Persian fallow deer.

GENERAL CHARACTERS. Pelage coloration is the most variable of any species of deer, with four main color varieties: white, menil, common (typical), and black (Chapman and Chapman, 1975). Intermediate pelage colors are cream, sandy, silver-grey, and sooty (Whitehead, 1972). Typical pelage is darker on the dorsal surface than the ventral surface, chest, and lower legs. A black dorsal stripe extends from the nape of the neck to the tip of the tail and around the upper edge of the white rump patch. Typically, white spots are evident on the back and flanks, with fewer on the neck and none on the head or legs (Chapman and Chapman, 1975). Spots on the lower sides and haunches fuse into a white line. In Persian fallow deer, a white line is evident on each side of the dorsal stripe. The dorsal stripe is more brownish in Persian fallow deer and markings around the caudal area are less distinctive (Harrison, 1968). Summer pelage color is generally dark reddish-brown dorsally grading to white ventrally (Whitehead, 1972). Spotting is more pronounced in summer than winter pelage. Haltenorth (1959) described in detail pelage color and characteristics, and associated seasonal changes of Persian fallow deer.

Both sexes have suborbital, rear interdigital, and metatarsal glands. Metatarsal glands are surrounded by pale hair that forms an oval 40 mm long and 35 mm wide. A scent gland is associated with the penis (Chapman, 1977), and there is a distinctive tuft of

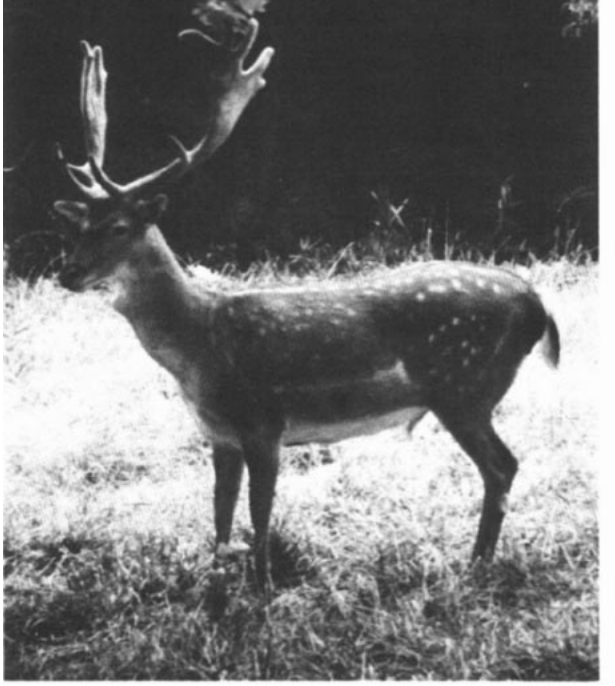

FIG. 1. Adult male fallow deer with characteristic palmate antlers, prominent "Adam's apple," and spotted pelage. Photo courtesy of D. Sharp, Tennessee Valley Authority, Land Between the Lakes, Kentucky.

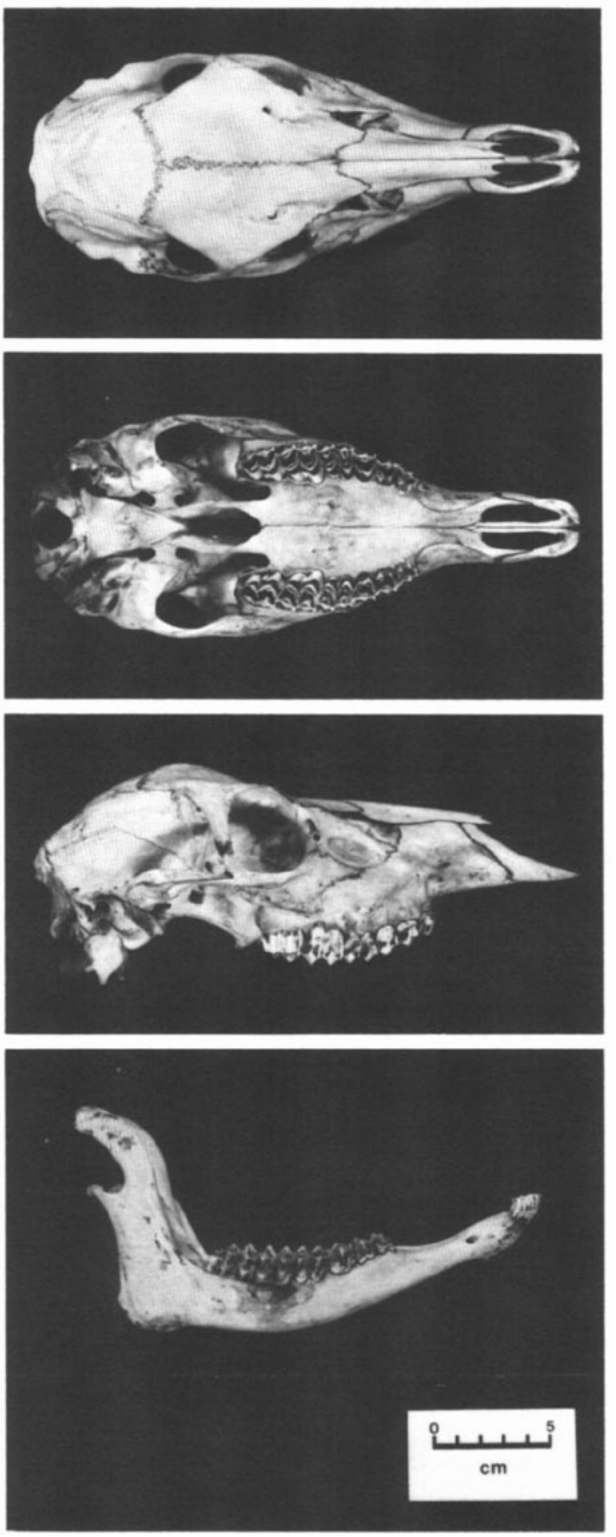

FIG. 2. Dorsal, ventral, and lateral views of cranium and lateral view of mandible of a female *D. d. dama* (Southern Illinois Univ. 2475 from Union Co., Illinois).

hair ("brush") about 12 cm long from the penis sheath or below the vulva.

Mean body mass (in kg) of neonates under park conditions in southeastern England were: males (n = 51) 4.6 (range, 2.5 to 5.9); females (n = 42) 4.4 (2.5 to 5.5). Mean live-mass of free-ranging adults were: males (n = 20) 67 (46 to 80); females (n = 15) 44 (35 to 52; Chapman, 1977). Sexual dimorphism is evident, with males exceeding females in most body and cranial measurements by about 4 to 14%. The following are mean cranial measurements (in mm) of adults from Scotland and England (free-ranging and park deer): condylobasal length, males (n = 47) 263 (range, 241 to 283), females (n = 46) 247 (231 to 267); zygomatic width, males (n = 69) 127 (115 to 140), females (n = 54) 109 (102 to 118); length of mandible, males (n = 68) 200 (185 to 216), females (n = 49) 191 (175 to 203; Chapman, 1977). Persian fallow deer are generally larger; condylobasal length of two adult males was 287 and 308 mm (Harrison, 1968).

DISTRIBUTION. Following the last glaciation the species is believed to have had a natural range in southern European regions along the Mediterranean Sea, Asia Minor, and possibly northern Africa and Ethiopia (Corbet, 1978; Harrison, 1968; Meester and Setzer, 1971; Whitehead, 1972). They are one of the most widely introduced ungulates (Fig. 3), with populations in about 38 countries from latitudes 61°N to 46°S in North and South America, the Leeward Islands, Europe, South Africa, Australia, New Zealand, and Fiji (N. G. Chapman and D. I. Chapman, 1980; Lever, 1985). There were unsuccessful introductions in Colorado (Presnall, 1958) and Massachusetts (Godin, 1977).

In Africa, fallow deer in Morocco, Algeria, Libya, and Tunisia probably have been extirpated for several centuries (Meester and Setzer, 1971). In the Middle East, fallow deer remain only in Turkey (Heidemann, 1973). Persian fallow deer formerly ranged in Iran, Iraq, possibly Jordan and Syria, southern Lebanon, and Israel (Ferguson et al., 1985; Harrison, 1968). Free-ranging Persian fallow deer probably occur only on the Dez and Karkheh wildlife refuges in southwest Iran, where combined population density is estimated to be only 40 to 65 (Department of the Environment Iran, 1978).

FOSSIL RECORD. Remains of *Dama* date from the mid-Pleistocene (400,000 years before present) first interglacial (Lister, 1984). The Clacton fallow deer (*D. d. clactoniana*), known from several European sites (Leonardi and Petronio, 1976; Sutcliffe, 1964) from the second interglacial (250,000 years before present), shows ". . . very close similarities to present day European fallow deer . . ." (Chapman and Chapman, 1975:37). References to early Pleistocene *Dama* in Europe (Azzaroli, 1953) and China (de Chardin and Trassaert, 1937) probably are erroneous (Lister, 1984; Sickenberg, 1965). Chapman and Chapman (1975) suggested that many of the 18 or more species of fossil fallow deer named are invalid or synonymous with Clacton fallow deer. Fallow deer probably were extirpated in Europe during the last glaciation (Chapman and Chapman, 1975; although see Zeuner, 1963), with the possible exception of sites in southern Europe (Bokonyi, 1971). The question of who first introduced fallow deer into northern Europe is unresolved. Phoenicians, Gauls, and Romans may have brought fallow deer to various regions; the Normans probably introduced them to Britain (Chapman and Chapman, 1975; Lister, 1984). Persian fallow deer have been reported from late Pleistocene sites in Iraq (Hatt, 1959) and Israel (Bodenheimer, 1960).

FORM AND FUNCTION. Molting occurs biannually. In England, the spring molt begins in April and lasts about 40 days. The autumn molt begins by the last week in September. The winter coat is complete by late October or early November (Chapman and Chapman, 1975). Johnson and Hornby (1980) contrasted seasonal pelage characteristics in a population of long-haired fallow deer with normal individuals. Long-haired deer always had a higher proportion of growing hairs than did normal deer and were characterized by long tufts of hair growing from the ears.

The mammary glands undergo a cycle of growth and regression annually. After parturition mass of the mammary glands is from 400 to 800 g (Chapman and Chapman, 1975). The udder remains large as the fawn utilizes only milk in its diet. The lactation period lasts approximately 9 months although there is much variation (Chapman and Chapman, 1975; Jackson, 1977*a*).

Fawns are born with 20 deciduous teeth. The eruption of the molars begins at 3 to 4 months of age. The last molar (M3) is not completely functional until 3 years of age. The permanent incisiform teeth begin erupting at about 7 months and are complete by 17 to 20 months of age. The permanent premolars begin erupting at about 17 months of age and are complete at 25 to 26 months of age (Chapman and Chapman, 1970). Ueckermann and Scholz (1980) examined sectioned incisors for age determination and found age in years was equal to the number of secondary dentine layers plus one.

Male fawns develop pedicels at about 6 to 9 months of age,

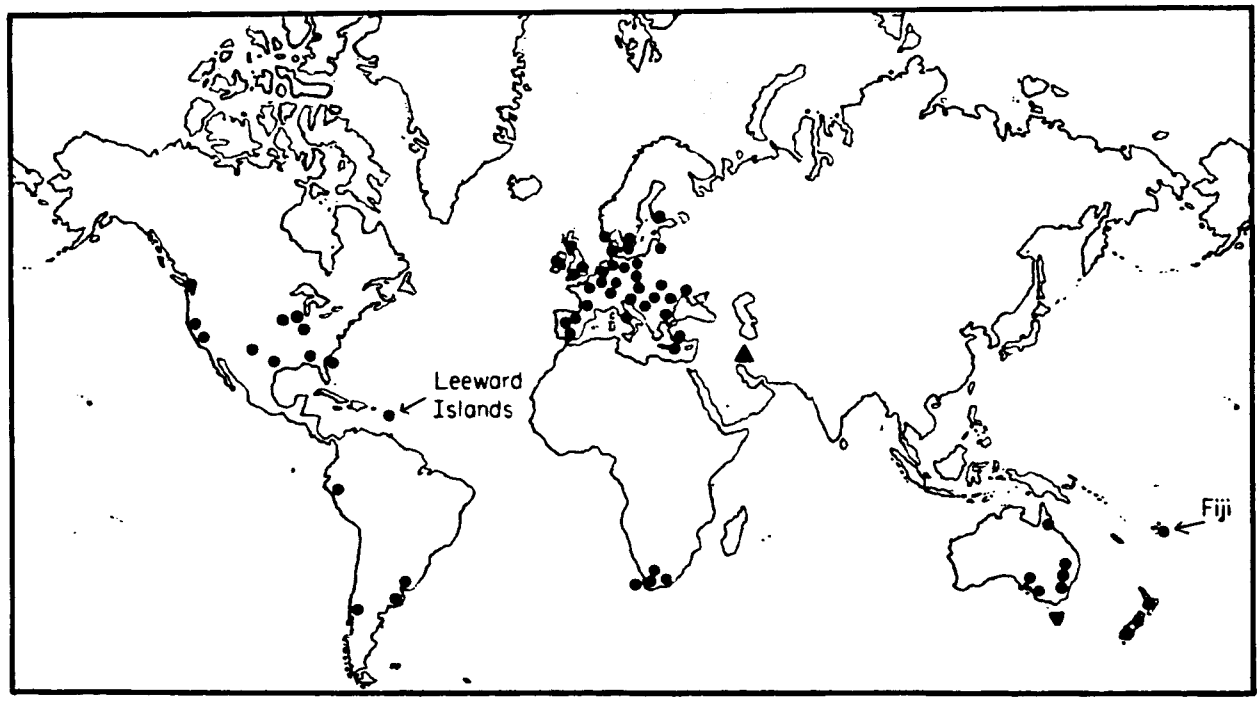

FIG. 3. Distribution of fallow deer (*D. d. dama*); single triangle in Iran denotes *D. d. mesopotamicus*. Modified from N. G. Chapman and D. I. Chapman (1980). Reprinted with permission of Blackwell Sci. Publ., Ltd., Oxford.

concurrent with an increase in diameter of the seminiferous tubules (D. I. Chapman and N. G. Chapman, 1980; Chapman and Chapman, 1982). In the northern hemisphere antler velvet is shed in mid-August and the antlers are cast between April and June (Chapman and Chapman, 1975). Connolly (1981) found that yearling bucks clean the velvet earlier and cast their antlers later than mature bucks. Antler growth commences as soon as the old set is cast and takes about 3 months to complete (Eaton, 1980). In three fallow deer monitored, levels of keratan sulfate, a cartilage-related glycosaminoglycan, were high in developing antlers. Levels dropped when antler growth ceased and they became completely mineralized (Dinsmore et al., 1986). Abnormal antler cycles may be induced by stress (Topinski, 1975).

Chapman et al. (1982) measured concentrations of hemoglobin, packed-cell volume, plasma viscosity and other factors in 42 fallow deer. For all age groups, values for hemoglobin and packed-cell volume were significantly greater in females than males. In adult males, mean plasma viscosity was greater than in females, although this may have been affected by seasonal factors. A study of the hematology and serum biochemistry of adult females and fawns <6 months old revealed that hemoglobin, total red-cell count, packed-cell volume, lymphocytes, inorganic phosphorus, alkaline phosphatase, and creatine kinase were significantly higher in fawns. Fawns had significantly lower red cell indices, eosinophil numbers, glucose, and urea nitrogen. Age-related differences were expected, as composition of blood in other species of deer does not reach adult values until at least 6 months of age (English and Lepherd, 1981). The arterial system of the head of fallow deer is similar to that of red deer (*Cervus elaphus*) and roe deer (*Capreolus capreolus*; Godynicki, 1972).

The internal organs of fallow deer contribute a significantly greater proportion of body mass (27%) than in red or roe deer (about 23%). Most of the difference is because fallow deer have more rumen-reticulum tissue relative to body mass (Nagy and Regelin, 1975). The ratio of caeco-colon to rumen capacity for fallow deer is about 1:14 to 15 (Hofmann, 1985). The mean length of the small intestine of six fallow deer was 11.9 m (Westerling, 1975), about 15 to 17 times length of body. The ratio of small to large intestine is 78:22, indicative of "grass-preferring, intermediate" feeders (Hofmann, 1985:404), as opposed to "concentrate selectors" such as moose (*Alces alces*) or white-tailed deer (*Odocoileus virginianus*). The mean proportion of carcass mass to body mass (in kg) for 48 fallow deer in Hungary fed supplemental rations was 72.8 ± 1.0 (Nagy and Regelin, 1975). During the rut, males lose an average of 17% of their body mass, and the liver exhibits steatosis, which is reversible (Sterba and Klusak, 1984). For males 13 to 25 months old raised on pasture in New Zealand, mean composition of the carcass was as follows: fat, 9.1%; muscle, 73.9%; bone, 13.6%; water, 66.7%; lipid, 7.0%; ash, 4.6%; and protein, 21.7% (Gregson and Purchas, 1985).

ONTOGENY AND REPRODUCTION. In the northern hemisphere the rut generally occurs in the second half of October (Chapman, 1970). The highest percentage of fertilization (82%) occurs during the rut, although females are receptive between September and January. Females are polyestrous and in the absence of pregnancy may cycle up to seven times during a 135-day breeding season (Asher, 1985). However, most females conceive during their first cycle. The length of the estrous cycle is 24 to 26 days (Chapman and Chapman, 1975). Asher (1985) reported mean cycle length was 22.4 days (±1.3 *SD*), and that it increased and became more variable as the breeding season progressed. Fallow deer usually give birth to one fawn (Chapman and Chapman, 1975). Twins occur in <1% of births (Sterba and Klusak, 1984). Well developed fawns may become pregnant when 6 to 7 months old (Ueckermann and Hansen, 1968), although females generally conceive for the first time at 16 months of age. The gestation period is about 33 to 35 weeks (Asher and Adam, 1985; Chapman and Chapman, 1982; Fischer, 1983). Increased serum progesterone levels associated with short-lived corpora lutea and "silent heat" may occur before the initial behavioral estrus. Ovulations without behavioral estrus also may occur after the breeding season (Asher, 1985). In fallow deer 3 years and older, the minimum percentage of conception is about 90% (Sterba and Klusak, 1984).

The first stages of spermatogenesis occur at 7 months of age, culminating with appearance of spermatozoa at 16 months (Chapman and Chapman, 1975; Chapman et al., 1981). The testes and epididymides of fallow deer 15 to 16 months of age are 10 times larger than those of fawns (Chapman, 1970). The testes and associated reproductive organs exhibit seasonal variation in growth after puberty (Chaplin and White, 1972; Chapman and Chapman, 1979; Kennaugh et al., 1977). Eversion of the transition zone of the prepuce initially occurs at about 17 months of age (Chapman et al., 1981). Males are physiologically capable of breeding at this age as the testes contain all the developmental stages of spermatozoa. Except in heavily hunted populations, however, males generally do not breed until they are 4 years old (Sterba and Klusak, 1984).

Considering the ontogeny of fallow deer, at 24 days of age

crown-rump length is 8 to 10 mm. Four days later it is 10 to 13 mm and the eyes are pigmented. By 35 days average crown-rump length is 19 to 20 mm, pinna are apparent, and follicles of vibrissae are present on the upper lip. Female gonads are evident at this stage. By 45 to 49 days crown-rump length is 3 to 5 cm and mass is 2 to 3.5 g. Toes of the pelvic limb are separated, palate is fusing, and ossification is beginning. The ribs and liver are apparent under translucent skin and there are no eyelids. Short hairs appear around the eyes and the skin is no longer translucent at 18 weeks when crown-rump length is 26 cm and mass is 465 g. At 25 weeks crown-rump length is 31 cm, mass 1,850 g, and there are fine, short hairs covering the fetus, which may be spotted. The fetus is fully developed at 33 weeks with crown-rump length of 55 cm and mass of 4,500 g (Chapman and Chapman, 1975; Sterba and Klusak, 1984). Fawns may be born from mid-May through summer in the northern hemisphere (Chapman and Chapman, 1975). The majority of fawns are born in the first part of June (Sterba and Klusak, 1984). For fallow deer raised on farms in New Zealand, mass of fawns at birth was positively related to both their date of birth and mass of the mother. Fawns <3 kg birthmass had a significantly higher mortality rate (67%) than heavier fawns (Asher and Adam, 1985). Lactation may continue until the following spring (Chapman and Chapman, 1975; Jackson, 1977*a*).

Mean mass (in kg) and measurements (in mm) for male (n = 4) and female (n = 7) fallow deer at birth, 3 months, and 6 months, respectively, are: weight—5.3, 4.7; 22.1, 17.3; and 31.8, 24.8; length of body—738, 665; 1,085, 1,011; and 1,171, 1,081; length of ear—102, 95; 137, 130; and no measurements for 6 months; height of shoulder—447, 434; 630, 600; and 695, 649; and circumference of chest—410, 372; 663, 612; and 820, 749 (Krzywinski et al., 1984). Males become fully mature and reach their greatest mass from 5 to 9 years of age; females between 4 and 6 years of age (Velek, 1973). Fallow deer in zoos have lived for 20 years or more (Ueckermann and Hansen, 1968).

ECOLOGY. Fallow deer occur in a variety of climates ranging from cool-humid to warm-dry areas. Most populations are found in a warm-humid climate. The habitat utilized is often a combination of vegetation types. Fallow deer prefer older forests interspersed with areas of grass, but can live in a diversity of habitats. They are found in mixed forests, broad-leafed forests, subalpine vegetation, grasslands, woodlands, scrublands, and savanna (N. G. Chapman and D. I. Chapman, 1980; Gray, 1983; Lister, 1984).

Fallow deer are gregarious when undisturbed and may be found in groups nearly all year. The size and composition of groups is dependent on the environment, population size, season, time of day, and degree of disturbance. Adult males are usually solitary, but in the summer, after antler regrowth, they may form small bachelor herds of less than six. The largest groups occur just prior to rut when males join the female herds. The smallest female herds occur during the fawning season. These increase when the fawns begin following their mothers (Chapman and Chapman, 1975). Group size is larger in open than in closed habitat (Schaal, 1982). In New Forest, England, groups ranged from 7 to 14 deer (Chapman and Chapman, 1982). In Kentucky, size of groups varied with time of year, time of day, and sex composition of the herd. In summer, the average group size was 3.6 in woods during the day and 5.2 in open fields at night (range, 1 to 45). Mixed, female, and male herds averaged 9.2, 14.0, and 2.1 deer, respectively (Farris, 1986). Herd stability is greater in female groups than in bachelor herds, with males resting at greater individual distances than females. Males disperse in individual flight rather than fleeing together as do females (Heidemann, 1973).

Size of home range varies depending on availability of food, shelter, degree of disturbance, climate, and density. Males occupy two seasonal home ranges; one during rut and one when they are in bachelor groups (Chapman and Chapman, 1975). These two home ranges may or may not overlap. In general, males have larger home ranges than females and move more within those ranges. With the exception of males during rut, fallow deer do not establish territories (Chapman and Chapman, 1982).

The sex ratio of 49 embryos and fetuses was 1 male : 1.2 females (Sterba and Klusak, 1984). Neonatal sex ratio was 1:1 (Asher and Adam, 1985; Ueckermann, 1972). The fawn : adult female : adult male ratio in California was 46:100:43 (Wehausen and Elliott, 1982). Sex ratio of adults depends on several factors including time of year censused and management regime, especially hunting. A female-biased adult sex ratio is typical. In most areas, the sex ratio ranges from 25 to 60 males/100 females (Chapman and Chapman, 1975; Dzieciolowski, 1979; Farris, 1986; Ueckermann, 1972).

Peak feeding periods occur at dusk and dawn in many areas, but fallow deer may forage at various intervals throughout the day and night. They are adaptable in forage used, and diets depend on season and availability. In Hampshire, England, the diet was divisible into three phases. From March through September grasses were the main food, with herbs and broad-leaf tree browse. From October to December, mast was the major food. Primary dietary components the remainder of the year were dwarf shrubs (*Calluna vulgaris*), bilberry (*Vaccinium myrtillus*), ivy (*Hedera helix*), bramble (*Rubus fruticosus*), rose (*Rosa* sp.), holly (*Ilex aquifolium*), grasses, and coniferous browse (Chapman and Chapman, 1975; Jackson, 1977*b*). In California, diet of fallow deer consisted of 90% grasses and 10% browse (Connolly, 1981); Wehausen and Elliott (1982) found the deer used grasses (*Lolium perenne*, *Bromus mollis*, and *Festuca dertonensis*), forbs such as *Plantago lanceolata* (seeds and leaves), *Hypochoeris radicata* (flowers and leaves), and *Lotus corniculatus*, and browse such as *Rubus vitifolius*, *Cytisus scoparius*, and *Myrica californica*.

In North America, fallow deer are sympatric with mule deer (*Odocoileus hemionus*) and white-tailed deer; there probably is some competition for forage in certain cases (Chapman and Chapman, 1975). Fallow deer also may compete with livestock for forage (Connolly, 1981). At Point Reyes National Seashore, the annual diet of fallow deer consists of more grass and less browse than that of black-tailed deer (*O. h. columbianus*; Elliott and Barrett, 1985). There was little interspecific competition between fallow deer, roe deer, and red deer in Scotland (Batchler, 1960).

Potential predators of fallow deer in North America include mountain lions (*Felis concolor*), bobcats (*F. rufus*), black bears (*Ursus americanus*), and coyotes (*Canis latrans*; Chapman and Chapman, 1975). There are no remaining natural predators of fallow deer in Great Britain. Most mortality occurs in deer <1 or >7 years old. Induced mortality is related to man or dogs. Hunting and poaching are primary causes of mortality in England (McDiarmid, 1974). Deer-vehicle accidents are most common from October to January, associated with the rut and subsequent break-up of the herd (Chapman and Chapman, 1975; Geissler, 1981). Sex ratios of road-killed deer are generally equal although in some areas apparently more males are killed (Chapman and Chapman, 1969; Geissler, 1973).

Ectoparasites reported from fallow deer in Europe include lice (*Solenopotes burmeisteri* and *Damalinia tibialis*), keds (*Lipoptena cervi*), nasal bot flies (*Cephenemyia multispinosa* and *C. rufibarbis*), fleas (*Paracerus melis*), and ticks (*Ixodes ricinus* and *Haemaphysalis punctata*; Chapman and Chapman, 1975; Jackson, 1975; Kadulski, 1975; Sleeman, 1983). In North America, ectoparasites include lice (*Bovicola tibialis*), keds (*L. depressa* and *Neolipoptena ferrisi*), nasal bot flies (*C. apicata*), and ticks (*I. pacificus*, *I. scapularis*, *Amblyomma americanum*, *A. maculatum*, and *Dermacentor albipictus*; Connolly, 1981; Hunt and Gilbert, 1981; Westrom et al., 1976).

Endoparasites of fallow deer summarized by Chapman and Chapman (1975) included 57 species of nematodes, 6 species of cestodes, and 4 species of trematodes. Additional nematodes reported in fallow deer from Europe include *Cysticercus taeniae*, *Ostertagia drozdi*, *Skrjabinagia lyrata*, *S. ryjikovi*, *Spiculopteragia suppereai*, and *Strongyloides papillosus* (Barth and Matzke, 1984; Hinaidy and Prosl, 1978; Jancev, 1979, 1981; Kotrla and Kotrly, 1975). Fallow deer are a host for *Dictyocaulus eckerti* (Romano and Persiani, 1982), *Cutifilaria wenki* have been found subcutaneously (Schultz-Key, 1975), three species of protozoans (*Eimeria auburnensis*, *E. faurei*, and *E. ninaekohlyakimovae*) were reported (Pav et al., 1975), and *Sarcocystis* have been found (Drost and Graubmann, 1975). Nematodes associated with fallow deer in North America are *Apteragia odocoilei*, *Bunostomum phlebotomum*, *Capillaria bovis*, *Gongylonema pulchrum*, *Haemonchus placei*, *Nematodirus odocoilei*, *Oesophagostomum venulosum*, *Parelaphostrongylus tenuis*, *Setaria tundra*, *S. yehi*, *Skrjabinagia odocoilei*, *Spiculopteragia assymetrica*, and *Thelazia californiensis* (Chapman and Chapman, 1975; Connolly, 1981; Davidson et al., 1985; Kistner et al., 1977; Phillips et al., 1974). Thirty-one species of known or potential helminths of fallow deer in New Zealand have been listed (Yerex, 1982).

Fallow deer in England and the United States have shown

evidence of avian tuberculosis (*Mycobacterium avium*). Pseudotuberculosis and brucellosis also have been found (Chapman and Chapman, 1975). They may be susceptible to *Brucella abortus* under abnormal conditions such as game farms (Roberts et al., 1976). In Tasmania, two fallow deer were infected with the bacterium *Erysipelothrix rhusiopathiae*, and one with *Leptospira grippotyphosa*. In England, one deer was found with *L. icterohaemorrhagiae*, and in Germany sera from fallow deer contained antibodies against *Leptospira* (Chapman and Chapman, 1975; Weber and Christoph, 1981). Antibodies against the coccobacillus *Pasteurella multocida* have been found in serum samples (Weber, 1985). In Alberta, parainfluenza-3 and herpesvirus have been found (Kinyili and Thorsen, 1979; Thorsen et al., 1977). These deer were susceptible to foot and mouth disease either through innoculation or contact with diseased animals (Forman and Gibbs, 1974; Forman et al., 1974). Antibodies to epizootic hemorrhagic disease and blue-tongue viruses were found in fallow deer from Kentucky (Davidson et al., 1985).

Fallow deer have been enclosed or herded at least since the time of the early Greeks. They were reported in deer parks in Scotland as early as 1290, and by the 16th century were the most common species in deer parks in Britain. They are used extensively in modern deer-farming operations. In 1981, there were about 20,000 fallow deer on farms in New Zealand. There are approximately 200 deer farms in West Germany, all of which have fallow deer (Fletcher, 1984). The species is farmed for both venison and antler velvet. In 1979, velvet from fallow deer was worth $200/kg, with an average yield of 0.7 kg of grade-A velvet/deer (Luick, 1982). Velvet from fallow deer is not considered to be good quality, and the deer are difficult to handle. They also are prone to facial eczema resulting in chronic ill-thrift or death (Yerex, 1982).

The best time to census fallow deer populations probably is late winter or early spring. In addition to direct counting, abundance has been estimated from fecal accumulation (Bailey and Putman, 1981). Adult deer have been trapped using food and water as a lure, or an estrous female during the rut, cannon netting, driving deer into nets, netting across well-travelled routes or from helicopters, and by drug immobilization (Nall et al., 1970; Searle and Parker, 1982). Drugs commonly used for immobilization include fentaz, rompun, ketamine, scoline, acepromazine, and mixtures of etorphine and xylazine, plegicil, or azaperone (Erickson, 1970; Harrington and Wilson, 1974; Nall et al., 1970; Searle and Parker, 1982).

BEHAVIOR. During summer adult males often are solitary, but by early autumn they begin joining the female groups (Chapman and Chapman, 1975). During this preliminary rut, males spend most of their time establishing a territory, the rutting stand. Adults mark their stand by pawing the ground to create "scrapes" into which they may urinate. They also thrash understory vegetation with their antlers and deposit scent from the suborbital glands. During the preliminary rut, males produce low-pitched groans and grunts, belch, and spar with other males. There are two peak activity periods for preliminary rutting displays, 0530 to 0800 h, and 1630 to 1800 h (Espmark and Brunner, 1974). The rut usually peaks in mid-October (April in the southern hemisphere), as does the occurrence of fraying, thrashing, groaning, and sparring.

Fallow deer are polygynous and onset of the rut is characterized by presence of females on the stands. During this time, males may stop feeding. Subordinate males unable to establish their own territory often stay on the periphery of the herd. When a subordinate enters a territory, the rutting male will chase it off. During the rut, a male sniffs and licks the anal area of the female and hair below the vulva, probably to determine if she is in estrus (Chapman and Chapman, 1975). The male approaches the female several times. Usually she utters a high-pitched whine and moves away. She eventually allows the male to mount; copulation may last as long as 5 min (Packard, 1955), but usually is about 10 seconds.

The terminal phase of the rut is characterized by changes in animal activity and group size (Espmark and Brunner, 1974). Males eventually form small bachelor groups. Young males may disperse when 9 to 12 months old or stay with the female groups until they are about 18 months old, at which time they join a bachelor herd. Adult females, fawns, and yearlings remain in groups of 7 to 14 after the rut, but may form larger groups in favorable feeding areas (Chapman and Chapman, 1982).

Prior to parturition pregnant females become secretive and look for a hiding place. However, some females give birth near the herd (Chapman and Chapman, 1975). Parturition usually occurs during the period of day of least activity (Meier, 1973). Immediately after birth, the mother licks the fawn to clean it and help establish the mother-young bond. Females do not return to the herd for 2 to 10 days following parturition (Cadman, 1966). They also remain separated from their fawn for most of the day, returning only to nurse it. Initially the dam is responsible for recognizing her fawn and re-establishing contact. Later the fawn learns to recognize its mother's bleat. The fawn remains in the same area for about a week. If disturbed, a fawn initially reacts by flattening on the ground and remaining motionless. Within 48 h postpartum they may attempt to flee, at least for short distances (Gilbert, 1968).

When nursing, the fawn stands in the opposite direction of the mother and at a slight angle. The mother often licks the fawn around the anal area to stimulate suckling, urination, and defecation. Nursing periods occur about every 4 h until the fawn is 4 months old. Grasses may be eaten a few days after birth, but rumination does not begin until 2 to 3 weeks of age (Chapman and Chapman, 1975). Weaning is initiated by the mother when the fawn is about 20 days old (Gauthier and Barrette, 1985). Mothers gradually decrease the amount of time fawns are allowed to nurse, but they are not completely weaned until about 7 months of age (Chapman and Chapman, 1982). When fawns are 3 to 4 weeks old, they begin following their mothers and groups of about six deer are formed; 2 to 3 weeks later adult females and fawns form much larger groups (Chapman and Chapman, 1975). Mothers begin decreasing maternal care by decreasing the duration of tactile contacts (Farris, 1986).

The daily activity of fallow deer varies depending on time of day and year, food availability, amount of disturbance, sex, and age. They may be active at any time, but exhibit peak activity periods at dusk and dawn. Deer are more vigilant in open areas and in smaller groups (Schaal and Ropartz, 1985). Females also are more vigilant than males and may increase their vigilance when fawns are present (Farris, 1986; Schaal and Ropartz, 1985). Fallow deer spend most of their time feeding, resting, and moving, depending on reproductive status and diet quality (Chapman and Chapman, 1975; Farris, 1986; Putman, 1980). Diet also affects defecation rates (Rollins et al., 1984).

Six types of vocalizations have been described for fallow deer (Gilbert, 1964). Barking is a short, loud, explosive alarm call produced by females. Other vocalizations are: bleating, a short, medium-high pitched sound produced by females close to parturition or with young fawns; mewing, a higher-pitched sound given by deer of any age during submission postures; peeping, a high-pitched sound produced by fawns in distress, or to establish contact with their mother; wailing, an intense distress sound produced by fawns older than 2 days; and groaning, a low belch-like sound produced by rutting males (Gilbert, 1964). Each groan lasts about a second, but may be produced in a series with 4 to 5 s between groans (Chapman and Chapman, 1975).

Alerting, the most common type of visual communication, is an upright stance with the neck extended vertically and the body held rigid. The entire herd may assume this posture when disturbed (Gilbert, 1964). Stiff-walking (exaggerated stepping movements) also occurs under stress situations. Tail positions may communicate degree of alarm (Alvarez et al., 1976) and head positions are used as threat signals (Gilbert, 1964). Tactile signals such as touching, licking, pawing, nipping, and butting mainly occur between adult females and fawns, but also may occur between adults (Gilbert, 1964). When alarmed, fallow deer may respond to the source of disturbance by walking, trotting, strutting, galloping, or pronking (Alvarez et al., 1976). Strutting is a slightly exaggerated, rhythmic trot. Pronking is a stiff-legged, bouncing movement usually seen when deer are slightly disturbed or surprized, although fawns also pronk when playing. When fleeing, a female tends to lead with the herd following single file by decreasing leadership rank (Gilbert and Hailman, 1966).

GENETICS. The diploid number of chromosomes is 68. Two autosomes are metacentric and 64 are acrocentric or telocentric. The sex chromosomes are an acrocentric X and a submetacentric Y (Hsu and Benirschke, 1967); X is the largest chromosome and Y is one of the smallest (Gustavsson and Sundt, 1968). There are significant amounts of heterochromatin at all autosomal centromeres, and terminal nucleolar organizing regions on the two largest acrocentric pairs of chromosomes (Mayr et al., 1987).

Blood and tissue samples from 794 fallow deer from 37 sites in England and Wales revealed no electrophoretic variation at 30 loci; fallow deer in Britain have a lower level of variation than other

cervids, probably because of a historic bottleneck (Pemberton and Smith, 1985). Likewise, no polymorphism was found in transferrin from 65 fallow deer (McDougall and Lowe, 1968), and only one hemoglobin type was reported in 62 specimens examined (Maughan and Williams, 1967). Conversely, two major hemoglobin types and three or four minor components from three fallow deer were found by isoelectric focusing (Butcher and Hawkey, 1977).

There are similarities in highly repetitive DNA sequences in certain cervids, despite variations in chromosome number. Relative to fallow deer, a higher degree of homology exists between the repetitive DNA sequences of moose, reindeer (*Rangifer tarandus*), and roe deer (Lima-de-Faria et al., 1984). There are no definite records of fallow deer hybridizing (Chapman and Chapman, 1975). Only sterile matings resulted from two female fallow deer and a male black-tailed deer in captivity (Wurster and Benirschke, 1967).

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