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SEASONAL ASPECTS OF MAN/CATTLE INTERACTION IN BRONZE AGE WESTERN INDIA

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ABSTRACT.—Pastoral mobility has been implicated in the instability of the settlement pattern of Gujarat, Western India in the second millennium BC. The site of Oriyo Timbo, analyzed to further investigate this relationship, displayed indications of temporary pastoral settlement in its lack of solid architecture, thin deposit, location in a non-agricultural zone, and abundance of animal bones, but other evidence complicated this interpretation. A seasonal determination of the deaths of archaeological zebu cattle was attempted via microscopic examination of annual rings in tooth cementum. Annular analysis revealed a clustered pattern of deaths during the dry season months of March to June. These data suggest that Oriyo was a dry season cattle camp associated with more sedentary occupations in nearby areas. Further interpretation concerns the role of herd migration in regional culture change.

INTRODUCTION

The passing of the seasons gives rise to a profound periodicity in the management of domestic herd animals. Seasonality is evident in a wide variety of activities, but certainly one of the most obvious is the movement of animals between different pasture regions in a well-defined yearly cycle. Movement promotes the well-being of the herd, since grasslands used for any length of time will become degraded if not left to regenerate. Herders who exploit neighboring but contrastive environments may also find that different pastures mature and decay in sequence over the year. Under these sorts of circumstances, movement between pastures maintains grazing quality, and prevents the nutritional plane of the herd from plummeting at regular intervals.

Seasonal mobility can benefit the herdsman as well. Migration allows larger herds than can be grazed on the territory of a single settlement, helping to increase pastoral production. Mobility can also have political advantages, exemplified by the Yomut Turkmen of Northeastern Iran, who use migration to avoid taxes, feuds, and government control (Irons 1974, 1975:70-72). Here, migration is a strategy for successful stockraising as much as stockraising is a strategy for successful migration.

While the numbers and influence of seasonally migrating pastoralists are dwindling in the face of agricultural expansion and government settlement schemes, history records periods when these groups made for a potent force for social and cultural change. The Arabian Bedouin, conquering for Islam, and the Mongol warriors each put their permanent stamp upon the lands of the Old World; before them the Scyths and Cimmerians threatened Classical society, while the Biblical Amorites ravaged the landscape of Mesopotamia.

In prehistory, pastoral migration has been associated with the earliest domestication of herd ungulates. Neolithic sheep and goats of the Iranian Zagros are thought to have been led between summer campsites in the mountains and winter villages in the lowlands (Flannery 1965:1250; Mortensen 1972:296). This cycle may have been simply the mobile component of a sedentary agricultural economy, involving village livestock under the care of village shepherds, but the existence of a more specialized pastoral nomadism as early as 6000 BC has been suggested by the remains at Tepe Tula'i on the Khuzestan Plain (Hole 1974a, 1974b).

The economic and political significance of mobile pastoralism, its impact upon the historical record, and its presumed antiquity suggest that seasonally migrating pastoralists have played major roles in a wide variety of prehistoric contexts. This paper aims to investigate that premise, with reference to Bronze Age South Asia. Specifically, it will examine the issue of seasonality in zebu cattle herding, as it pertains to the archaeological record of Western India in the second millennium BC. Seasons of death of cattle at the pastoral site of Oriyo Timbo will be estimated from patterns of annual rings in dental remains. Season of death will in turn be used to infer the portion of the year in which cattle herds passed through this settlement. This study attempts therefore to reconstruct one segment of the yearly round of a group of cattle pastoralists, in hopes of creating insight into the general herding pattern of the time.

A PROBLEM IN SOUTH ASIAN CULTURE HISTORY

The seasonal analysis of Oriyo Timbo is designed to shed light on the role of pastoral migration in the Bronze Age settlement dynamics of Gujarat State, India. During the late third and early second millennia BC, Gujarat witnessed oscillations over time in site counts, site size, and the character of the settlement grid (Possehl 1980:49-67). At this time Gujarat was an important region of the Harappan Cultural Tradition, comprising the Indus Valley Civilization (ca 2500-2000 BC) and the simpler farming communities which preceded and followed it. The chronology of Harappan Gujarat is defined by ceramic changes, grouped into four phases, at the site of Rangpur in the area of Saurashtra (Fig. 1; Rao 1963). In phase IIA, contemporary with the Indus Civilization,

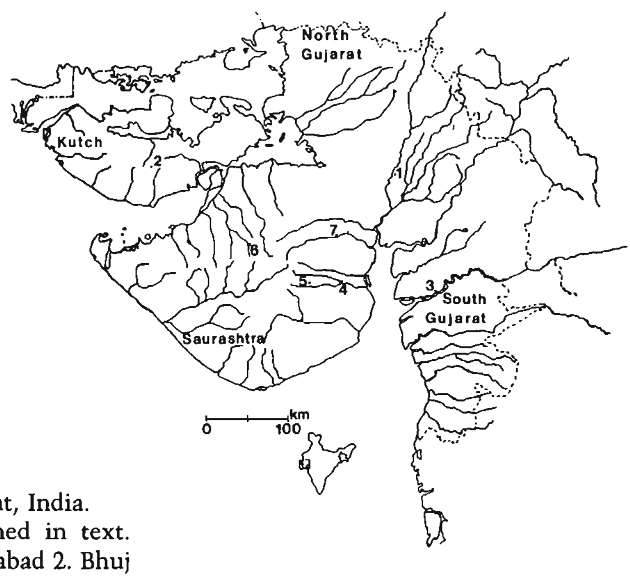

FIG. 1.—Gujarat, India. Places mentioned in text. Key: 1. Ahmedabad 2. Bhuj 3. Broach 4. Nesadi 5. Oriyo 6. Rajkot 7. Rangpur.

a cluster of towns and cities was situated in Kutch, while settlement was sparse throughout the remainder of the state. North and South Gujarat bear no firm trace of permanent occupation, nor does much of Saurashtra. In the phases that follow the collapse of the Indus urban centers (Rangpur IIB and IIC), settlement undergoes a dramatic transformation. The number of known sites increases greatly in all parts of Gujarat but Kutch. Settlement expansion is especially evident in Saurashtra in the form of an integrated system of towns and villages. This trend is short-lived however, because the next period, Rangpur III, is marked by a decline in settlement. Site counts drop, from over 120 to nearly 30, and average site size also decreases where this information is available. (Site counts are current to 1980. Many new sites have been discovered since, but the trends in settlement remain unchanged. See Bhan 1986.)

The decline in settlement in Rangpur III seems to have intensified to the point that any permanent occupation continuing beyond this phase is unknown. Excavated sites with Harappan occupations are generally abandoned at the close of the Rangpur sequence (ca 1400 BC; Possehl and Rissman in press). Those that are not exhibit stratigraphic gaps or other types of material discontinuities between the Harappan and Iron Age periods (Sankalia 1974:383; Mehta *et al.* 1975:4). Firm evidence of village settlement does not re-appear until shortly before the Mauryan period of the late fourth and early third centuries BC, and may be closer to the time of Christ (eg. Mehta 1968). Thus the Rangpur III period not only marks the end of the Harappan Tradition in Gujarat (Harappan material culture continues for varying lengths of time in other regions of South Asia), but also a hiatus in settlement of approximately 1000 years.

These fluctuations may have been influenced by the changing priorities of cultivation versus herding. Possehl (1979, 1986) has suggested that during Rangpur IIA times, much of the open space in Gujarat and elsewhere in the Indus Basin was occupied by migratory pastoralists, whose campsites would not be recognized by archaeologists on survey. Possehl (1986) has also argued that the expansion of settlement in Rangpur IIB/IIC is related to the sedentarization of some of these groups following the introduction of domesticated millets into the subcontinent from East Africa. Finally, a re-emphasis of herding over farming by part of the settled population may have been responsible for the drop in site counts during Rangpur III and after. In this light, further investigation of cultural dynamics in Harappan Gujarat should consider in greater detail the role of migratory pastoralism.

THE SITE OF ORIYO TIMBO

To investigate the significance of pastoral migration in Bronze Age Gujarat, the mound of Oriyo Timbo, near the village of Chiroda in eastern Saurashtra, was chosen for seasonal analysis. Oriyo, excavated in 1981/82 by a combined team from the University Museum, Philadelphia, and the Department of Archaeology of Gujarat State, is dated to the Rangpur III period, the final phase of the Harappan Tradition in Gujarat, by ceramic criteria (Rissman 1985). A number of material characteristics indicate the site may have been a temporary pastoral camp: these are the ephemeral quality of its architecture and habitation deposit, its anomalous location relative to other, presumably agrarian, sites in the region, and faunal evidence of significant quantities of cattle remains.

The temporary character of the occupation at Oriyo is suggested by a lack of solid architecture. Although much of Oriyo has been damaged by the plow, undisturbed Rangpur III habitational material was excavated from one stratum. Preservation of features and artifacts in this stratum was quite satisfactory. Among the finds were a series of hearths, both dug into and sitting upon a fossil ground surface, and a number of bovine hoofprints. The hearths, in the absence of any evidence for industrial activity, were apparently for domestic purposes. Firm evidence of domestic architecture was totally lacking, however. Walls, floors, post-holes and even chunks of daub were missing from the material inventory. In fact, the only possible architectural feature was an arc of stones from a disturbed context that may mark the remains of a tent or windbreak. The depth of occupation residue is also relevant. Although evidence for settlement is spread across four hectares, the average thickness of deposit may be estimated at no more than 60 centimeters.

The notion of temporary residence is supported by Oriyo's location. The site is situated on a plain between the Ghelo and Kalubhar Rivers; the Ghelo passes 8 km north of the site while the Kalubhar flows 4 km to the south. The placement of the site between the two rivers is unusual for the Harappan settlement pattern of the region. Possehl (1980) surveyed the Ghelo and Kalubhar Valleys and mapped 57 sites of all periods from Harappan to late historic. Of 36 Harappan sites discovered, all but Oriyo were situated within 200 meters of the banks of either river. Twelve other sites were mapped between the rivers, but only Oriyo dates earlier than the second or third century BC. Possehl (1980:52) has argued that the river bank location may have been oriented to land kept free of dense vegetation by periodic flooding, allowing the practice of agriculture without the need to clear away undergrowth. If so, then Oriyo's distance from the rivers may imply that ease of cultivating was not a prime factor in its location.

This suggestion is reinforced by a soil analysis carried out by Dr. K.T.M. Hegde of the Maharaja Sayajirao University of Baroda, Gujarat (Hegde, unpublished communication), which indicates that the ground surface upon which the Harappan occupation began was formed under conditions of poor drainage. This stratum is rich in clay and humus, and contains remains of *Lacrominacroix*, a reed that grows in swampy soil. Hegde speculates that prior to the Harappan occupation the area may have been damp for ten months a year. This seems to be due to local drainage conditions, reflecting impoundment of monsoon run-off, rather than climate change. This layer drained and was exposed to weathering for some time before the Harappan occupation started, but in light of the local quality of the marsh sediment, it is a viable possibility that Oriyo remained in proximity to wetlands throughout the Harappan period. If Oriyo was truly oriented toward marsh rather than arable land, a pastoral function would gain further support. In Gujarat seasonal marshes are used extensively for grazing and constitute some of the region's finest pasture (Bose 1975:6; Patel 1977:20).

Finally, the excavated faunal evidence is consistent with a pastoral interpretation of the site. Cattle, presumably of the zebu variety *(Bos indicus)*, outnumber all other identified species by a wide margin, and comprise 75-78% of all bone fragments in every type of context. Other identified species include sheep *(Ovis aries)*, goat *(Capra hircus)* and domestic (?) pig *(Sus scrofa)*, as well as a few wild representatives of bovid, cervid, and small mammal populations. Cattle remains are not only abundant relative to other species; their density argues for a high level of pastoral activity as well. The densest area of the site produced 896 cattle bone fragments representing a minimum of 25 individuals. This figure reflects an excavated volume of about 80 cubic meters. If this density were extrapolated across the entire site area of four hectares, assuming an average 60 cm deposit, over 8000 head of cattle would be projected, albeit over an unknown time span. From a more disturbed operation, 110 bone fragments yielding three individuals were excavated from 60 cubic meters. If this density were extended over the site, a minimum of 1200 individuals would be represented at Oriyo. These numbers cannot be taken too literally, since a random sampling procedure was not utilized during the fieldwork. Either figure strongly suggests, however, that an impressive number of animals died or were slaughtered at the site, and that Oriyo was the location of a sustained and committed, rather than casual, pastoral effort (the density of cattle remains could suggest that Oriyo was a butchery site for the surrounding region, but the distribution of meat bearing elements to total elements indicates consumption was primarily on-site).

Despite these suggestions of temporary pastoralist occupation, other evidence renders such an interpretation rather tenuous. The presence of a cultivated millet, *Eleusine cf. coracana*, in the botanical material (Wagner 1983), and grindstone fragments in the artifactual assemblage indicate that some form of agricultural activity may have been carried out on site. Heavy storage jar fragments and the possible presence of domestic pig, an animal that is not normally herded with cattle, further argue against the migratory nature of the site's inhabitants. Moreover, the arguments for seasonal pastoralist residence cited above are subject to certain weaknesses of inference. For example, the criteria of architecture and thickness of deposit are plagued by biases associated with negative evidence. The disturbed nature of the habitation may conceal the remains of permanent structures, while occupational residue may once have been more substantial, but has since been diminished by erosion. The criterion of location seems overly deterministic as well. There is no inherent reason why the area could *not* have been used for cultivation; indeed, Oriyo is under cultivation currently. Finally there is no way to confirm that the abundant faunal remains do not simply represent the cattle raising component of a sedentary agricultural village. Thus the evidence is equivocal as to whether Oriyo was actually the home of seasonally migrating pastoralists.

To help resolve this ambiguity a seasonal analysis of herd occupation was attempted. If herds were found to be quartered at Oriyo year-round then the interpretation of a poorly preserved sedentary agricultural village would receive support. If herds were found at the site only at certain seasons however, then Oriyo could be designated a stopping point for migrating animals.

Unfortunately, until recently the tools for measuring seasonal herd, as opposed to human, occupation were woefully inadequate. One of the salient characteristics of pastoral mobility is that it often does not involve the entire human population. When herds migrate, it may be under the care of a few herders, while certain categories of people, especially the elderly, infants, and perhaps adult females, remain within a less temporary settlement. Biological indicators of seasonality, such as the bones of migratory birds, remains of commensal rodents (Hesse 1982; Tchernov 1984), and mollusc shells which preserve seasonal growth increments (Monks 1981) have often been utilized to fix the time of year of site occupation. But while these possibly constitute accurate measures of human seasonality, they do not at all measure herd movement. If one wishes to chart the movement of herds one cannot rely on indicators of human seasonality. One must rather measure seasonality directly from the herds themselves.

One direct measure of herd seasonality has received wide application—this is the examination of herd age structure from tooth eruption and wear patterns in mandibular remains, and the determination of season of death by reference to a restricted birth season (Higgs and White 1963; Bokonyi 1972). For example, if sheep remains show that for a high proportion of individuals the lower first molar was erupting when death occurred, then many deaths at the age of about six months may be assumed. If sheep are known to be born in the spring, then it may be further assumed that sheep occupied a particular settlement in the fall (at the least). This technique suffers from poor reliability however, because eruption times in archaeological fauna must be guessed from modern (or several centuries old) data. Rates of growth and development in domesticated herd animals vary widely according to breed and management conditions, thus ages of tooth eruption have changed significantly, but in unknown increments, over time (Silver 1970:295-299). Aging animal remains to three or six month intervals is highly inaccurate when the ages at which teeth erupt in thousand year old specimens must be guessed from modern representatives.

A MORE APPROPRIATE METHODOLOGY

This research utilizes the analysis of annual rings, or annuli (sing: annulus), in the teeth of archaeological faunal remains, for seasonal determination of herding. Examination of annuli can accurately fix season of death of fauna at pastoral sites, indicating the time of year that herds were quartered in a settlement. Such analysis is a direct measure of herd seasonality, but does not share the disadvantages associated with tooth eruption sequences. Moreover, this technique is relatively new, and has not previously been applied to the seasonal analysis of a domestic herd ungulate faunal assemblage. The technique assesses microscopic annuli in a dental substance known as cementum.

Cementum is a mineralized collagen, structurally analogous to bone, which coats the roots of the teeth in all mammals. It is formed continuously over the life of the tooth. The substance is created when cells called cementoblasts deposit collagen around their membranes (Ramfjord and Ash 1979:49), and then infuse this fibrous matrix with crystals of hydroxyapatite (Selvig 1965:423). Annuli in cementum are observable under magnification as narrow, usually dark (depending on the method of observation), highly calcified bands. While there is no well-accepted explanation for their physiological origin, current opinion suggests they arise from periodic variations in build-up of the collagen matrix. Klevezal' and Kleinenberg (1969:22) suggest that a constant rate of calcification, combined with periodically slowed growth of collagen, will generate the narrow yet calcium rich increment. But whether or not it is controlled by the metabolysis of protein, the fomation of annuli does seem to reflect the seasonally slowed growth rate of the organism.

Since the 1950s a large number of studies have correlated patterns of incremental lines with annual periodicities. It was discovered that among temperate zone terrestrial mammals one narrow, dark line formed in the late fall, winter, or early spring, while during the warmer months a broad, lighter band was deposited (Sergeant and Pimlott 1959; Mitchell 1963; Mundy and Fuller 1964; Novakowski 1965). The narrow band, arising from slowed growth, will be herein termed a rest line; the broad band will be referred to as the growth zone. By counting the number of rest lines, an estimate could be derived of the number of winters an animal had survived, hence it absolute age. In this way wildlife biologists have extensively examined the age structures of temperate zone seal, whale, ungulate, carnivore, insectivore, and rodent populations.

Compared to this abundance of data, research on the dental annuli of tropical and sub-tropical animals has been sparse. Primarily a variety of East and South African bovids (Spinage 1967; Simpson and Elder 1969; Rautenbach 1971; Robinette and Archer 1971; Grimsdell 1973; Simpson 1973; Spinage 1976) have been examined. Tropical animals may form one or two rest lines per year, a pattern that is correlated with the number of dry seasons per annum in their home range. In the tropics it appears that annual rings reflect seasonal variations in moisture rather than winter weather.

Still more obscure are the annular studies of domestic animals and man. Stott, Sis and Levy (1982) met with success in aging three human cadavers from their cemental annuli, claiming a high degree of accuracy. Grue and Jensen (1979:37) also observed incremental lines in human teeth, but it was not possible to isolate primary lines from secondary laminations and consequently no age determination was possible. Similarly, it was concluded that annuli could not be correlated with seasonal cycles in Danish dogs kept as house pets (Grue 1976:4). On the other hand, domestic sheep from New Zealand, and Danish dairy cows and pigs were successfully aged, despite the provison of fodder throughout the year and sheltering during the winter (Saxon and Higham 1968, 1969; Rudge 1976; Grue and Jensen 1979:37).

ARCHAEOLOGICAL APPLICATIONS

Archaeologists developed an interest in annular analysis beginning in the late 1960s (Saxon and Higham 1968, 1969), and broadened the scope of inquiry to include season of death as well. The first seasonal determinations were published by Benn (1974) and Kay (1974), both using white-tailed deer from Woodland sites in the Midwest. In the last ten years additional seasonal and aging studies have been carried out on archaeological remains of several species of seal (Spiess 1976, 1978; Fletemeyer 1977; Morrison 1983), caribou (Spiess 1979:148, 191; Gordon 1982), musk ox (Savelle and Beattie 1982), and cattle (Coy, Jones and Turner 1982). This body of research has shown that annular analysis is a viable technique for both age determination and estimating season of death of archaeological fauna.

Season of death of an individual animal is assessed by examining the outer edge of the cementum deposit, the layer in formation at the time the animal died. If the outer layer was a rest line, death during the winter (or dry season) would be indicated. A growth zone at the outer edge of the tooth would imply that death occurred in late spring, summer, or early fall (or the rainy season). Greater accuracy has been claimed (Spiess 1976; Savelle and Beattie 1982:125; Gordon in press), based on a comparison of the width of the outer layer, either rest line or growth zone, with the widths of the analogous inner layers. For example, an outer growth zone that is half the width of the inner zones might suggest that the individual represented died mid-way through its growth season, or in mid-summer for a temperate zone animal. An outer growth zone as wide as the inner zones would indicate death after a completed growth season, perhaps in the autumn.

When the seasonal data for each tooth are aggregated, the result is a slaughter schedule that indicates the relative proportions of the fauna that died in each part of the year. The schedule is then analyzed for clustering and gaps in season of death. A uniform pattern would indicate slaughter throughout the year. A sharp concentration of slaughter times, in the absence of evidence for death at other times of the year, would instead point to a marked seasonality in killing with further consequences for pastoral organization.

PREPARATION AND RECORDING OF SPECIMENS

Annuli in this study were examined in dental thin sections, observed with polarized light using a petrographic microscope, a standard procedure for archaeological specimens (Morris 1972). Sections were prepared in the following manner: conjoined teeth were sawn apart with a hacksaw, leaving the jawbone intact around the roots. Individual teeth were then impregnated with epoxy. Teeth were sectioned longitudinally along the lingual-buccal plane with a Buehler Isomet slow-speed rotary saw and the sawn face was glued to a glass slide. The tooth was sawn a second time on the Isomet, parallel to the slide and as close to the face of the slide as possible. The specimen was then ground on a wheel and finally by hand on a glass plate until a thickness of 35-40 microns was attained.

Slides were observed using a Vickers petrographic microscope under magnification of 50 to 100x. For each tooth the number of rest lines was recorded as well as the character of the outermost band. The latter variable was recorded in one of four ways. When the outermost layer of cementum was a rest line, a death in the season of slowed growth was noted. Second was the case in which a rest line was outermost but traces of a growth zone could be seen forming on portions of the root. This instance was marked as a death during the seasonal transition from slowed growth to the beginnings of normal metabolysis. Third and fourth were instances in which the growth zone was the outermost layer of cementum. This zone was distinguished as being in its early or late phase of apposition by comparison of the outer and inner growth zones. If the outer growth zone was one half or less the widths of the inner zones, a death in the early part of the growth season was recorded. If the outer growth zone was greater than half the widths of the inner zones, a death in the latter part of the growth season was noted.

THE CONTROL SAMPLE

The first step in any annular analysis of ancient fauna must be a corresponding analysis of modern animals, of identical species and habitat. This is due to uncertainty about the causes of variable cementum growth rates that give rise to annulus formation. Relationships between climate, diet, hormonal cycles and cementum formation are too obscure to correlate the annular sequence of any animal with a specific environment based simply on theoretical expectations. It is important to recall that annuli will form in humans, housepets, and domestic animals in the absence of environmental variation, even if they do not always assume a periodic pattern. Therefore, before any annular analysis is attempted on an archaeological sample, the exact seasons at which annuli form in the ancient fauna must be previously known through empirical study of a modern population of recorded age and dates of death. Once the seasons of rest line formation have been determined for the modern sample, these data will serve as a seasonal control to which the archaeological material is calibrated, obviating the need to rely on the murky relationships of climate, nutrition and metabolism.

Certain limits to data collection precluded a perfect match of species and habitat between the modern control sample and the Oriyo material. Given Indian sensitivity to the cow it was neither wise nor practical for the control sample to utilize the dental remains of *Bos indicus*. Therefore the mandibles of water buffalo *(Bubalus bubalis)*, a closely related member of the tribe of Bovini, were substituted for those of zebu cattle in the control study. Other herd animals were easily available, so that a sample of sheep and goat teeth was also acquired. A number of pig mandibles were collected to complete the range of domestic ungulates typical of Western India.

Habitat was also imperfectly matched to the ancient sample but in an insignificant fashion. The problem of environmental change through time is not serious, for there is solid evidence that the modern climatic regime of Western India is little changed from that of the second millennium BC (Ghosh and Lal 1963; Singh *et al.* 1974; Seth 1978). But while some of the control specimens were collected in Gujarat, practical constraints necessitated that most of the sample of modern teeth come from the area around Delhi. Environmental differences between Delhi and Gujarat include marginally more precipitation in the capital during the monsoon and in winter as well, somewhat colder winters, and a more variable length of day. The pattern of seasonality however, with monsoonal rains from June to September, a warm dry period until November, cool weather from December to February, and hot dry weather from March to early June, is identical in both places. It was therefore expected that the pattern of annulus formation would not vary significantly between the two regions, and indeed this has been confirmed by analysis.

Along with species collected and locality of collection, the date and age of death were recorded. The teeth of freshly killed animals were gathered during the months of November, February, and July. Age at death was estimated from the tooth eruption tables provided by Silver (1970) for sheep, goat, and pig, and from MacGregor (1939; cited in Grimsdell 1971:37) for water buffalo. One sheep specimen in the advanced adult stage was aged by tooth wear according to the scheme of Payne (1973:293). In all, 15 animals, consisting of six buffalo, three pigs, four goats, and two sheep were examined for incremental lines. If this range of species agreed in the timing of rest line formation, confidence would increase that *Bos indicus* follows a general Western Indian domestic ungulate or bovid pattern.

ANNULAR RESULTS OF THE MODERN SAMPLE

The incremental pattern as recorded from modern animals of known age and season of death clearly suggests that rest lines form under seasonal influence. Of the seven animals killed in November or February, all had a majority of teeth with nearly completed growth zones at the outer edge of the cementum (Fig. 2). Of a total of 37 sections from seven animals, 32 agreed with this pattern. In these Western Indian animals, the months of November through early February fall into the latter portion of the growth season.

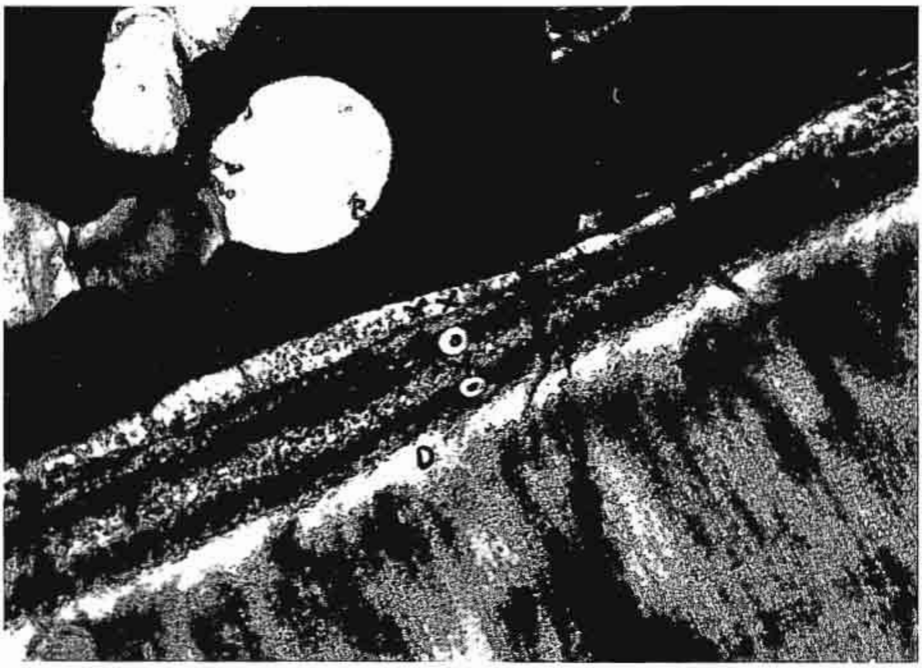

FIG. 2.—Section of deciduous lower third premolar from water buffalo killed in February. O = rest line, X = growth zone, XX = outer growth zone, D = dentin. Magnified 44x.

The animals killed in July are opposite in their indications. Of 24 teeth from eight animals, 19 had the beginning of a growth zone forming at the outer edge of the cementum (Fig. 3). This strongly implies that the month of July falls within the early portion of the Western Indian growth season.

If July marks the beginning of the growth season, and February falls in the late growth season, the time of year during which rest lines are formed can be bracketed sometime within the months of February to July. This result is very satisfactory in light of our knowledge of bovine physiology as it is affected by the Western Indian climate. A definite 'comfort range' exists for tropical cattle that is related to air temperature. As the thermometer climbs about 80°F (27°C), homeostatic mechanisms of cattle are activated,

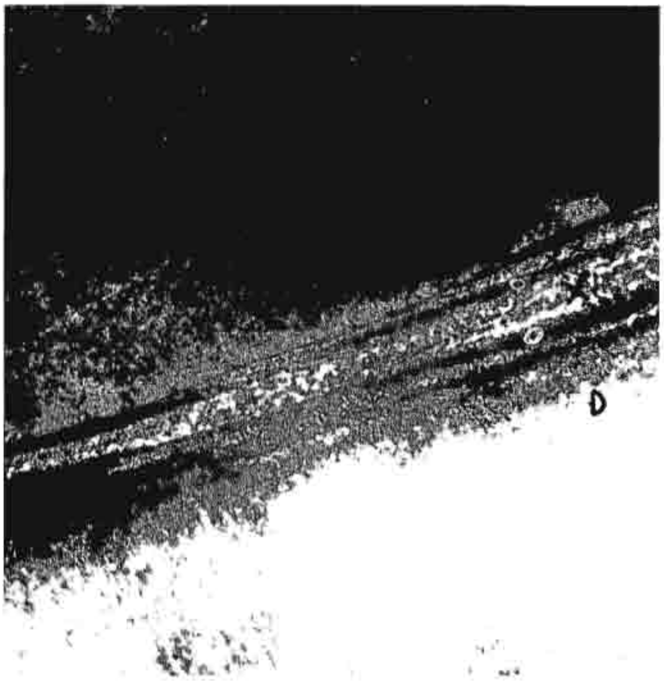

FIG. 3.—Section of lower first molar from pig killed in July. O = rest line, X = growth zone, XX = outer growth zone, D = dentin. Magnified 70x.

causing respiration and vaporization rates to increase (Williamson and Payne 1968:10). When the temperature rises above 95°F (35°C), these mechanisms begin to fail; as a result rectal temperatures rise, food intake declines, *metabolic processes such as milk production and growth slow down*, and a loss in body weight may occur. Studies suggest similar connections might be found for pigs, and possibly for sheep (Williamson and Payne 1968:10-11). In Gujarat and most of Western India mean maximum temperatures rise above 95°F in the months of March or April, and remain above this threshold until mid-June (Government of India 1964). The annular results agree perfectly with this climatic cycle.

Nutritional stresses are also at a maximum at this time. In Western India precipitation is most heavy from late June to mid-September. Between September and June, rainfall is extremely scarce. As the dry season progresses, water sources diminish and vegetation grows brown. The most difficult part of the dry season is just before the rains begin again; at that time, with moisture resources at a yearly minimum, the temperature climbs to its yearly maximum, and through increases in evapotranspiration adds signficantly to the loss of water. During these months, when moisture and pasture quality are both at their lowest point of the year, nutritional stress would be expected at its greatest level.

As animals killed during the months of March, April, May and June were not included in the sample, the precise times between early February and mid-July when the apposition of rest lines starts and stops cannot be further detailed. It is probably safe to assume however, that archaeological animals with outer rest lines were slaughtered in the four month period from March through June.

THE ARCHAEOLOGICAL SAMPLE

Archaeological cattle teeth from Oriyo were mainly recovered in a loose state, detached from mandible and maxilla, though a good number of teeth had fragments of jawbone adhering to their roots. All excavated teeth with roots remaining in place, a total of 62 from 52 sets of individual or paired teeth (some teeth were recovered in connected pairs), were used for the analysis.

Teeth of sheep/goat were mainly recovered intact within mandibles. Mandible halves from the left side of the jaw were used in most cases to ensure that each data point derived from a separate individual. Whenever possible, the first molar was selected for annular analysis. The first molar erupts earlier than the other molars and is coated with a greater amount of cementum, hence it displays a clearer annular pattern. Several fragmentary mandibles required the sectioning of other teeth than the first molar.

SEASONAL DETERMINATION OF ARCHAEOLOGICAL FAUNA

Of 62 cattle teeth from Oriyo, of which 20 were known to be pairs from the same animal, 36 teeth produced clear data on seasonality. Of these 36 teeth, eight were from pairs that had been separated.

The 36 teeth with seasonal data, representing 32 separate data points, show unequivocal clustering of slaughter in the season of rest line formation and shortly after. Of these 36 teeth, only four indicated death in the late growing season, approximately from October to February. When the sample is discussed below in relation to possible bias from differential preservation, it will further be asserted thxt three of these teeth are probably unreliable in any case. Six of thirty-six suggest death in the early part of the growth season, perhaps from the end of June until September/October. A portion of these teeth may also be suspect from the standpoint of preservation. Nine more teeth evidenced death at the end of the rest season and the beginning of the growth season. Death for these animals may have come at the end of June or the beginning of July. Finally, 17 of 36 teeth indicated slaughtering took place in the season of rest line formation from March to mid-June. In all, 26 of 36 teeth clearly show a clustered slaughtering period at Oriyo between March and July.

This cluster becomes even more obvious when the effects of burial and recovery are considered. A possible source of bias in the Oriyo materials is the differential preservation of tooth cementum on the roots of archaeological teeth. The outer layer of the cementum, containing the seasonal data, is the most likely area of the substance to be damaged in a buried context. When this is the case the seasonal indication will be misleading. The best way to guard against this is to segregate teeth into those that have been protected from abrasion to the roots by an adhering fragment of jawbone, and those that have unprotected roots. When compared, any discrepancy between the two groups should be noted. The Oriyo material illustrates this problem well. Below is a comparison of the two groups:

Season of Death

	rest	rest/early growth	early growth	late growth
Protected roots	12	4	2	1
Unprotected roots	5	5	4	3

While the protected growth is highly clustered about dry season slaughtering, with 16 of 19 teeth within this cluster, the unprotected group indicates a rather uniform slaughtering pattern throughout the year. Divided in this way, the teeth would appear to come from two different populations. This discrepancy should be interpreted as indicating the effects of attrition upon unprotected teeth, and should lead to a greater weight placed upon data from teeth with roots enclosed by bone.

Although the sample is much smaller, the seasonal indications of sheep and goat remains parallel to those of cattle, indicating a clustered dry season slaughtering pattern for these animals as well. Of ten firm seasonal data points, five indicate death in the period of rest line formation, two show slaughter at the boundary of the rest and growth periods, two fall into the early growth season and one marks a death in the late growth season. These proportions follow those of cattle closely enough to suggest that the seasonal slaughtering schedules of both large and small stock were identical, clustering strongly within the dry and hot period of March through June, and trailing off into the start of the monsoon in late June and July.

SEASONAL OCCUPATION VERSUS SEASON SLAUGHTER

While is seems clear that cattle and sheep/goats were slaughtered with a pronounced seasonal emphasis, it remains to be argued that such a pattern can indicate the actual season of occupation by domestic herds and herdsmen. The extension of reasoning from seasonal slaughter to seasonal occupation is based on a number of assumptions. One must accept that all dental remains have originated from animals that were slaughtered in the vicinity of the site itself, and that each individual was a member of a herd at the time of its death. These assumptions will place the herd at the site whenever deaths are evidenced. They will be violated if, for example, teeth were used as ornaments or tools and carried from place to place, animal heads had been carried to settlements from remote pastures, or if animals had been singled out of a far-off group, led to the site alone, and then slaughtered. (There is no evidence of the use of teeth for ornaments or tools at Oriyo, while the distribution of post-cranial bones suggests that entire animals are represented in the faunal remains.) If these assumptions are accepted, it follows that annular indications of death in the spring and summer will place the herd inside a settlement during the spring and summer, at the very least. Annular indications of death in every season constitute strong evidence that one is either studying a regime of sedentary pastoralism, or that the site was used seasonally but in random fashion through time.

This relationship is but one side of the coin however, because an absence of annular data for a particular season is no guarantee that animals had been removed to distant pastures; it simply means that they were not being killed. This complexity arises because animals are productive capital that must not be butchered aimlessly. Cattle are far more valuable for their milk, tractive power, and reproductive potential than they are for meat. For this reason slaughtering is generally restricted to non-productive animals, such as males in excess of breeding requirements, barren females, and animals approaching a natural death. Limits to the numbers of such animals force pastoral managers to be extremely conservative and reserve slaughter for special occasions, feasts, rituals, important visitors and the like, or for times of need when other resources are less abundant (e.g. Evans-Pritchard 1940:26; Schneider 1957:289; Spencer 1965:2; Cunnison 1966:30; Dyson-Hudson and Dyson-Hudson 1970:110; Monod 1975:94-98; Smith 1978:81). In areas with a marked ritual season or a pronounced season of scarcity, slaughter itself thus takes on a seasonal cast. Hence, an issue critical to the analysis is how one distinguishes animals that are present at a site, but not slaughtered, from animals that are not there at all.

One approach to this problem (see Rissman 1985 for additional suggestions) compares the slaughter schedules of a series of animal species, each of which might be expected to diverge in seasonal aspects of management or exploitation. For example, the slaughter patterns of domestic herd animals can be counterposed to those of wild species in the faunal assemblage. The same seasons of death for hunted and herded fauna could support an argument that the site from which they derive was unoccupied during other times of the year. In contrast, indications of year-round hunting would complicate any assertion of seasonal herd migration, although technically it would not refute such an assertion. A similar approach entails the comparison of season of death between domestic herd animals and more desentary domesticates such as dogs, cats, and pigs. Again, agreement in seasonal slaughter would reinforce an assessment of pastoral mobility, and divergence in season of death would serve as a warning signal.

A final comparison, with which the Oriyo data were evaluated, can be made between slaughter patterns of large stock, such as camels or cattle, and small stock like sheep and goats. Herds of small stock exhibit higher growth rates than large stock (Dahl 1979:270), and have less production capacity per animal; therefore the unit value of a sheep or goat is much less than that of cattle. The expenditure of a single sheep or goat is a relatively minor decision compared to the slaughter of a larger animal, and ethnographically small stock are butchered with greater frequency, and more informally, than large stock (Evans-Pritchard 1940:26; Schneider 1957:288; Spencer 1965:2-3; Cunnison 1966:30; Dyson-Hudson 1966:45; Monod 1975:94-95; Smith 1978:81). When a clustered slaughter pattern for large stock occurs alongside a more diffuse pattern for small stock, it may indicate a situation in which sheep and goats were butchered more regularly while cattle were reserved for special occasions. If, however, small stock exhibit a clustered season of death, corresponding to that of large stock, it may imply that both types of herd animals were away from the settlement except during the time of clustered killing. The Oriyo data suggest a slaughtering cluster of similar timing and magnitude for both large and small stock, from March to July in each case, which supports an argument for seasonal occupation of animal herds instead of simple seasonal slaughter.

An additional comment concerns the distribution of occasions at which butchering would be appropriate. While these occasions may be concentrated in particular seasons year after year, certain celebrations and rituals, such as birth ceremonies or funerals, as well as butchering in anticipation of natural death, would tend to have a more random occurrence. There may also be cultural preferences for meat intake that result in a low level of killing throughout the year (Smith 1978:80; Deshler 1965:165). For all these reasons slaughtering patterns can be assumed to cluster in certain parts of the year, but to persist in reduced frequency in other seasons, providing a relatively good measure of migratory herd movement even without the use of corrective tests. The rather obvious clustering of Oriyo herd animal deaths in the final months of the dry season seems quite convincing in this respect.

INTERPRETATION

The results of the annular analysis strongly reinforce the evidence of architecture, depth of deposit, site location and faunal remains in suggesting that Oriyo was a temporary, seasonal campsite of pastoralists. A reasonable reconstruction of lifeways at the settlement centers upon the arrival, sometime in the hottest part of the dry season, of cattle herds, accompanied by smaller herds of sheep and goats, led by a group of herdsmen. The animals may have been brought to Oriyo to take advantage of pasture and water offered by nearby marshland. The human residents used ceramics, manufactured chipped stone tools, and ground cultivated grain at the site. It does not appear that the site was occupied dj ring most of the yearly agricultural cycle (the normal growing season lasts from June to November), nor does it seem that it was situated in an agricultural zone; thus it may be argued that grain was carried to the site from another location in an unprocessed form. It is probable that a number of milch cows provided dairy products, and perhaps oxen were bled, while meat consumption of surplus or dying cattle was augmented with some hunting. The high density of cattle remains may further indicate that feasting took place as well. The herdsmen and their charges left Oriyo shortly after the first rains had commenced in late June, when pastures in less favored areas had begun to grow verdant. The site was apparently revisited in the dry season for a number of years, allowing the build-up of a thin, diffuse cultural deposit that eventually covered four hectares.

This interpretation is corroborated at the site of Nesadi, located near the point where the Ghelo and Kalubhar Rivers meet in eastern Saurashtra. Excavation revealed the rammed earth floors of several ephemeral structures associated with Harappan ceramics and the bones of cattle and deer [sheep/goat?] (Mehta 1984). Nesadi is located in a marshy area that floods during the monsoon, drying out several months after the rains have ended. These characteristics suggest that the site was not in a dry farming zone, and was seasonally occupied sometime within the dry season. The excavator is of the opinion that Nesadi was a cattle camp. If so, the data from Nesadi and Oriyo imply that in this region, dry season pastoral migration to marsh areas was a general aspect of Harappan herding strategy.

This derivation of regional herding practice, while useful in itself, sheds only limited light on the total pastoral system. A dry season camp represents a small fragment of the annual migratory cycle. In addition, no pastoral settlement, no pastoral economy is self-contained, thus research such as this begs the question of the wider subsistence economy within which pastoralism functions. That the Oriyo inhabitants were in contact with a more settled world is suggested by certain artifactual and biological evidence. Remains of millet do not seem to have been cultivated at the site. They may have found their way to Oriyo either through exchange with more settled communities or through transport to the site by herdsmen who were themselves agriculturalists at other times of the year, in other types of settlements. Remains of pig were judged to be domestic based on a single measurement of a third molar; these animals are unsuited to a life of mobility, and if domestic, probably arrived at Oriyo via the same routes as the grain. There is no evidence at the site for ceramic manufacture, so the pottery, including large storage jars, may also have been carried in from a more permanent residence.

Eight settlements nearby and contemporary to Oriyo are known from Possehl's survey of the Ghelo and Kalubhar Valleys (Possehl 1980:44). The closest to Oriyo is less than 5 km away. As mentioned previously, the sites are located on the banks of either river. Their size distribution is similar, ranging from one to four hectares and lacking in thick cultural deposit. Given their location in a presumed agricultural zone, there is no reason to doubt that these river bank sites were functionally equivalent, small-scale cultivating communities, able to supply the Oriyo inhabitants with agricultural and other products.

These settlements may have removed their cattle, along with some unknown part of their population, to marshlands in the dry season, implying that Oriyo was a satellite camp of the river bank villages. On the other hand, the small size and thin deposit of the river bank sites suggest that a temporary, pastoral character for these too cannot be ruled out. It is also possible that the Oriyo inhabitants came from farther away than the Ghelo-Kalubhar Valley, as part of an extended seasonal round. These issues will not be resolved until one of the river bank sites is excavated, its level of agricultural commitment estimated, and its seasonal character assessed.

FURTHER HYPOTHESES

Despite these unknowns, it is clear that pastoral mobility was one component of the Harappan economy, as well as a determinant of the settlement pattern, most obviously during the dry season. Its importance may have been considerable in the districts around Oriyo, where agricultural uncertainty is a severe problem. Eastern Saurashtra receives an average of 60 cm of rain per annum. This figure is deceptive because rainfall is very erratic from year to year. The vicinity of Oriyo experiences crop failure due to drought an average of one year in six (Government of Gujarat 1969:212). Another significant feature is the erratic distribution of precipitation over space. When one district is experiencing drought, an adjacent area is likely to be blessed with rain. This is illustrated in Fig. 4, which plots the yearly rainfall of four cities, representing North Gujarat, Kutch, Saurashtra and South Gujarat, from 1901-1950. In 28 years out of 50, some portions of Gujarat received below average rainfall while other areas were above average. In only 13 of 50 years did all four cities receive less than average rainfall simultaneously. Thus, the Harappan farmer of Eastern Saurashtra could gather two things about the monsoon: that with relative frequency, he would lose his crop and his livelihood, and that conditions would probably be better over the horizon.

In light of these environmental characteristics, pastoral migration may have represented a major safety valve for Harappan cultivators. In years of poor rainfall cattle would be utilized as a mobile productive resource, the only one that could accompany

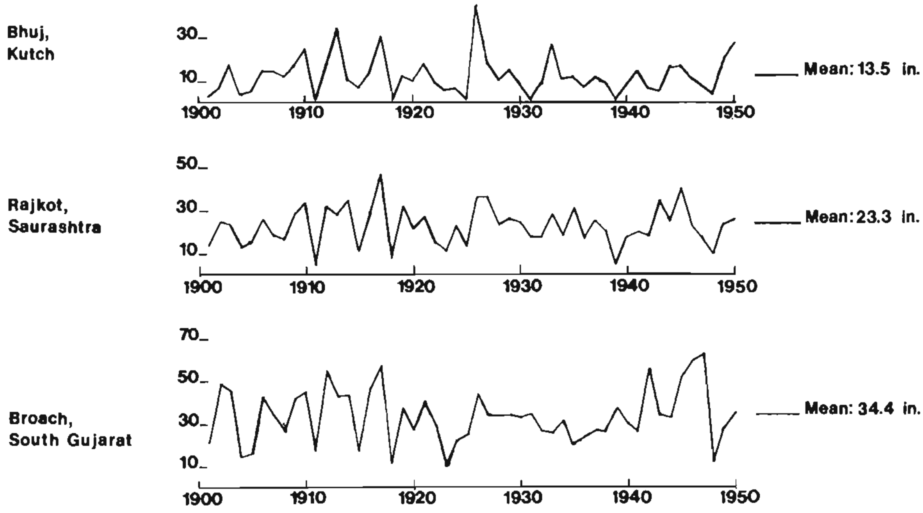

FIG. 4.—Yearly rainfall in inches for four cities in Gujarat, 1901-1950. Source: India Meteorological Department 1970.

a human population to more congenial surroundings until it could return to its land. One might further postulate that the importance of cattle as a mediator of agricultural risk meant that opportunities for nomadization were continually present in Harappan Gujarat. Cattle managers normally try to keep larger herds than is necessary for subsistence, partially to guard against disastrous losses from unforeseen calamities (Monod 1975:117; Dahl 1981:204). Under these conditions herd size is prone to grow past the threshold at which all of the animals can be kept in the vicinity of a single settlement. If this occurs, the herd owner must decide whether he will dispose of some of his animals, entrust them to a herder, or conduct them on a migratory round himself (Horowitz 1975:397-400). The desire of the herd owner to personally manage his stock, combined with the need for large numbers of animals, can thus lead to increases in mobility, or nomadization.

If this hypothesis has any merit, it will allow one to flesh out Possehl's concern with the instability of Harappan settlement, which culminated in the disappearance of Harappan material culture from Gujarat. We can envision a contradiction in settlement: on one hand, millet agriculture provided a plentiful source of calories in good years, encouraging sedentism. On the other, the need to keep large herds as a subsistence hedge must have exerted continual pressure for pastoral migration. One might imagine that during the Rangpur IIB and IIC periods, when settlement expanded rapidly, cultivation was a relatively successful strategy, but by the Rangpur III period and afterwards, migratory herding had gained the upper hand. I suggest that the timing of these shifts may be related to a third factor that mediated the tension between cultivation and herding, this being political administration.

One traditional role of government in South Asia has been the provision of relief during times of agricultural failure. The *Arthashastra*, a manual of political conduct dating back 2000 years, directs the king to set aside half the royal stores as insurance against public calamity (Bose 1961:146), while a third century BC inscription from Bengal records the measures taken by authorities to combat famine by issuing rice from reserves (Wheeler 1968:136). There are no records of this responsibility from earlier times. The Harappan distribution system seems to have been quite sophisticated however, implied by finds of rather standardized artifacts at far-flung outposts, in total covering a larger area than any contemporary polity. It is quite reasonable that subsistence goods as well as more durable items circulated in this system. The erratic spatial pattern of rainfall would favor redistribution, since a drought in one area was often balanced by adequate rain in another, enabling a regional authority to allocate its own resources in a more even fashion.

Harappan administration reached its highest point during the Indus Civilization (Rangpur IIA in Gujarat), but Rangpur IIB/IIC evidences some political complexity in the form of fortified settlements, public architecture, long distance trade (e.g. in gold), and vestiges of writing and measuring systems. Some of these traits persist in the Rangpur III period but the details of the transition are too poorly known to draw any conclusion of administrative trends. The relationship of political organization to subsistence and settlement must therefore remain only a hypothesis until testing is complete. The possibility is fair however, that there was a steady erosion in administrative capacity in concert with the decline of Indus urbanism, and a corresponding downward trend in the strength of the redistributive economy.If one of the functions of redistribution was to even out the erratic pattern of agricultural production, the risks of cultivating would have increased. Increasing agricultural risk would have enhanced the importance of mobility as an adaptive strategy, promoting the value of livestock. This would have encouraged increases in the cattle population, and the reluctance to reduce herd size as it approached local limits could have precipitated the nomadization that is postulated for Rangpur III and after. A telling point in this regard is that permanent settlement returns to Gujarat only with the re-appearance of centralized political authority in the late first millennium BC.

CONCLUSION

This paper has shown that seasonal aspects of man/cattle interaction can be identified in Bonze Age South Asia, that annular analysis is indispensable in this regard, and that migratory herding can be hypothesized to have great importance in the Harappan Tradition in Gujarat. Annular analysis is not only useful in South Asian archaeology, but is widely applicable to pastoral sites in other regions and other times, as dental remains of herd animals are generally abundant at these types of settlements. The method is relatively new, used for seasonal determination since 1974, and, to my knowledge, never systematically applied to a pastoral economy before the present study. Research into this topic and its capacity to illuminate herding strategies in South Asia and elsewhere deserves to be continued and intensified. Our grasp of seasonality in ancient man/animal relationships has much room for improvement, and a wealth of data, in the form of archaeological dental remains, lies in storerooms and within unexcavated settlements awaiting the analyst.

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Herbal medicine has generated a fair amount of controversy over the years. Its advocates recommend it as a more traditional, natural method of curing, safer and more wholesome than modern Western medicine. Its detractors, on the other hand, denounce herbal medicine and folk healing in general as dangerous, misguided, and unscientific, and maintain that it should not be seriously considered by any educated person. As with many controversies, the truth lies somewhere in between the two extreme viewpoints. Some herbal remedies used by folk healers do indeed perform the tasks attributed to them, in some cases more efficiently and more gently than refined modern drugs; in fact, herbs are the ultimate source of many of the refined drugs preferred by Western practitioners (e.g. *Ephedra* and *Digitalis*). Other herbal medicines yield no positive benefit whatsoever. Some are dangerous poisons, especially in large doses, while others completely lack any discernable physiological effect, though they may possibly have some salutary psychological effects as placebos or as parts of more encompassing healing rituals.

This book represents an invaluable source of information which may help researchers and health practitioners alike to ascertain the true physiological effects of a wide variety of plant species. The book concentrates on plants of dubious value, rather than on those obviously beneficial or dangerous; in fact, the author's original title for the book was "Borderline Herbs". The author predicts in the introduction that he will be criticized for not including plants which are not "borderline", and rightly so. What is perfectly obvious to one person is very often completely unknown to another. Making the book more inclusive would have added to its value as a reference volume.