Pastoralists Adjustment to Hematophagous Flies in Dhofar: An Analogy of an Ancient Adaptation.

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Abstract: *This is the result of an ethno-archaeological study that investigated the precautionary measures adopted by traditional pastoralists against hematophagous flies in Dhofar, Oman. The paper documents these traditional methods. It is known, that such practices do not leave any evidence in the archaeological context. It also examines these measures, which manifest a pastoral adaptation to this ecological limiting factor. The study maps the natural range of the flies and compares it with the distribution of archaeological sites recorded in Dhofar in order to establish a correlation between the two components. Traditional pastoral adaptation offers a framework to establish a reasonable parallel to prehistoric practices and adjustment. The measures probably manifest the interaction of an ancient human culture in Dhofar and its adjustment to an ecological limiting factor.*

Introduction

The saying "A bee can make the lion's eye bleed, but it neither roars nor claims to be the forest king" arises from traditional empirical knowledge and observation of creatures interacting with each other (cf. ElMahi forthcoming 1). Yet it signifies metaphorically the dynamic progression of ecological interactions and how these are manifested by the ways species (big or small) interact and with subsequent outcomes. Ecological interactions take place between two species which are biologically and morphologically different and thus result in varied consequences. Some species change or modify their adaptation while others, such as the bee, are not affected by such an interaction.

In any given ecosystem some species use a particular sting to influence the life of others. Not all outcomes of ecological interactions in any given ecosystem can be gauged, but one of the most significant that takes place in an ecosystem is caused by two categories of species known as enemies: predators and parasites. The effects these have on their prey and host vary in degree and magnitude from one to another. Although predation and parasitism act as a population check factor, they can also stimulate and augment species' survival through adjustment and adaptation.

Adaptation is one of the natural responses developed by all species, including humans. It is to secure survival through change in behaviour, function or structure. Human adaptation, however, can be more elaborate and complex than that of any of the other species in an ecosystem. Ecological Anthropology has addressed this idea extensively (cf. Barfield 2001:1-2). Vayda and Rappaport (1968) regard it as the interaction of extensive processes that take place between a human population and a particular ecosystem. It is the interplay of human culture and ecological conditions in order to survive and to adapt to the ecosystem (cf. Barfield 2001:137). It offers success in the constant struggle for survival.

Throughout mankind's history, certain insects have affected the life and ways of human groups. The effects vary from one ecosystem to another. An obvious example is the human

adoption of certain geographic movements in specific seasons. Identifiable flies have forced some human groups to adopt seasonal transhumant movements as is the case with the Nuer in southern Sudan (cf. Evans Pritchard 1949) and Dhofari goat and camel herders in southern Oman (cf. ElMahi forthcoming 2). The Shawawi in central Oman are also reported to move from one place to another (a cyclic movement) to avoid hornets and other disturbing factors (Birks 1976: 9). Similarly, flies have confined human groups to certain geographic territories. A good example can be traced back to medieval Sudan. The tsetse fly there blocked Arab migration beyond the Bahr Al Arab River and thus from deeply penetrating to the south. The fly's effect is described by ElMahi (1996: 100):

> "The Arab migrations into the Sudan covered wide geographical regions such as the plains of Kordofan, Darfur and eastern Sudan. They pushed deeper and deeper southwards into unpopulated or thinly populated areas. It seems that the most southern limits of those migrating groups were marked by the tsetse belt to which neither the Arabs nor their animals were tolerant".

Although they are small and have a short lifespan, these flies had direct and indirect effects that were difficult to defy by medieval or traditional societies. On the contrary, they forced these groups to make strategic adjustments such as limiting their geographical dispersal and marking and restricting their tribal territory. In essence, the flies influenced (perhaps dictated) vital characteristics in the life of many societies and their adaptations.

Today, in the Dhofar region of southern Oman there are three blood-feeding midges: *Lyperosia minuta, Musca crassirostris, and Forcipomyia lasiohelea*. They inflict considerable damage on humans and animals. Consequently, traditional pastoral groups carry out certain precautionary measures to protect themselves and their animals. Nonetheless, the current interplay between Dhofari pastoralists and these midges in the ecosystem has not been addressed by any scientific inquiry. An investigation of this ecological interaction is necessitated by the need to understand the human ecology and adaptation of prehistoric groups in Dhofar.

On the other hand, archaeological evidence clearly attests the human occupation of this area as early as the Lower Palaeolithic in the Stone Age (cf. Zarins: 2001). Nonetheless, these midges must have been present and active in the ecosystem a long time before man's occupation of Dhofar. The question is how Neolithic pastoralists survived such midges. Furthermore, does the distribution pattern of archaeological sites in Dhofar reflect the influence of these hematophagous flies in any way? This study attempts to answer these questions by examining the adaptation of traditional pastoralists in Dhofar.

The study

Examination indicates that Dhofari pastoralists have adopted a set of precautionary measures against hematophagous flies. Therefore, the study aims at identifying and documenting these measures taken against these harmful midges (Fig. 1). Second, the interplay between the traditional pastoral groups and the midges is in essence an ancient ecological interaction, which must have evolved as early as human occupation in Dhofar. Therefore, it also aims to understand an ancient human ecology and adaptation of pastoralism in this eco-region in southern Arabia. By doing so, it is possible to establish a reasonable analogy to prehistoric practices against such a hazard and hence cast

light on early pastoral ecology and adaptation. This analogy does not prove prehistoric pastoral practices in Dhofar, but only explains the possibility of parallel practices.

The study is also necessitated by the fact that archaeological evidence always falls short of explaining ancient ways that do not leave behind material evidence. Even material evidence cannot easily be associated with certain measures or strategies. What the archaeological context reveals is very limited when compared with the extent of practices of those whose remains and food waste archaeologists are trying to study. Moreover, such precautionary measures do not leave any material evidence for archaeology to unearth. Field anthropological and ethnoarchaeological studies have assisted archaeology by offering analogues to prehistoric practices. Therefore, a principal act of inquiry that archaeologists can pursue is to gain an understanding of such prehistoric practices.

Furthermore, the study will attempt first to map the present distribution of the hematophagous flies in Dhofar, and second to map an illustrative distribution of archaeological sites in Dhofar. These two will compare the distribution pattern of the archaeological sites against the hematophagous flies' natural habitat and distribution in that region.

The methodology of this study is based on informal interviews, personal observation in the field and mapping the distribution of the hematophagous flies. Interviews were carried out with elderly pastoralists in Jabal al-Gara, Jabal al-Qamar and Jabal Samhan. The information received from the local inhabitants was usually cross-checked with that from other groups of informants. Usually elderly informants were approached through a local mediator, who normally introduced the author to them. This proved to be very practical and facilitated reminiscing about the old days of the Dhofari pastoralism.

The mapping of the hematophagous flies' distribution in the three major areas of Dhofar (Jabal al-Gara, Jabal al-Qamar and Jabal Samhan) was carried out by Nasser Hamd Al Henahi (Dept. Archaeology, Sultan Qaboos University).

It is important to take a close look at the ecoregion, the archaeology of Dhofar, the people who inhabit this region, the flies themselves, and how they affect humans and livestock.

The Ecoregion of Dhofar

Throughout time, Dhofar has been an important region in southern Arabia (Fig. 1). Its coastal boundaries extend along the Arabian Sea southwest ward to Yemen. The Northeast parts of Dhofar are marked by desert conditions of sand dunes and stony plains. Historically Dhofar has witnessed significant events and developments. Since the time of the early Greeks and Romans, the Arabian Sea has facilitated a passage of trade and human contact and Dhofar was a renowned rendezvous. The sea has shaped the historical and socio-political growth and fame of Dhofar. Though the Empty Quarter, al Rub al-Khali, north of the Dhofar region, forms an inhospitable barrier, human contacts

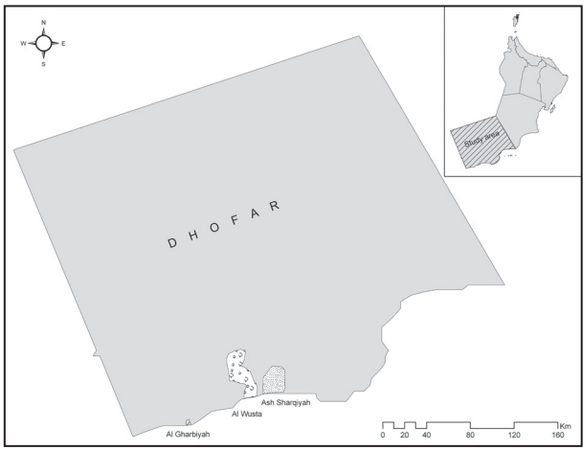
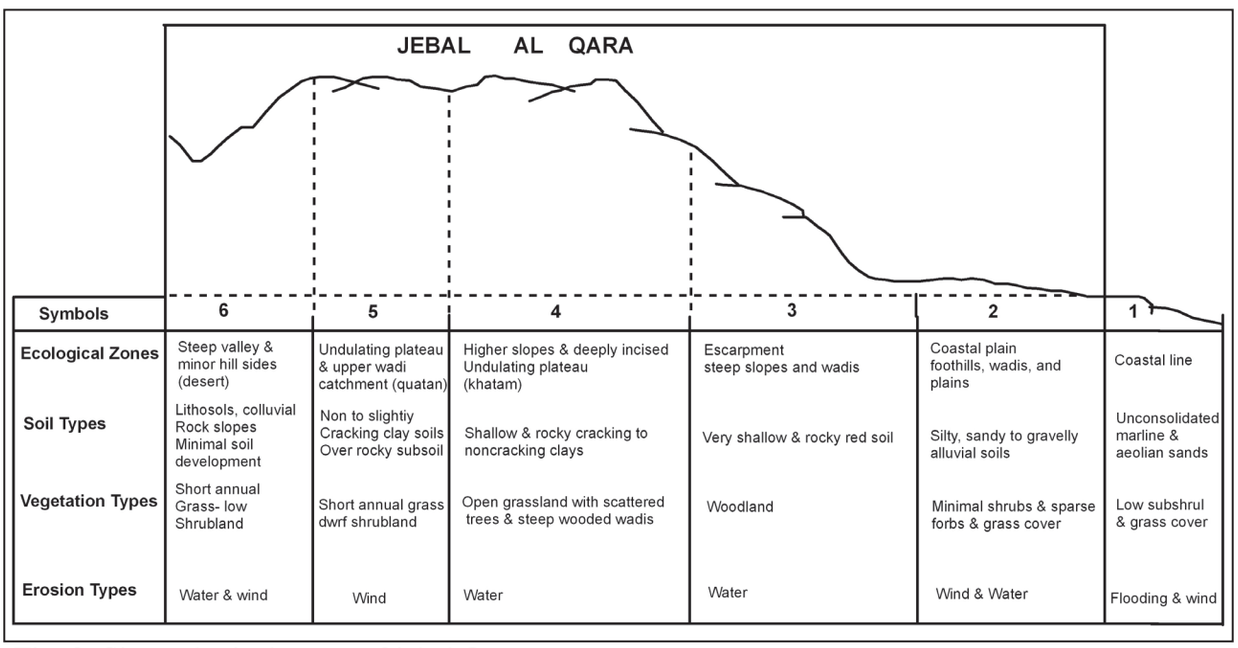


Fig. **1: Dhofar: the study area.**

were established before the introduction of the "desert ship," the domestic camel. Over the passage of time, the ecology and the location of Dhofar seem to have been influential elements in shaping socio-economic and political events in this region. In fact, Dhofar has a perceptibly unique biotope in the Arabian Peninsula.

The individuality of Dhofar's biotope in the Arabian Peninsula is shaped by its mountains and the monsoon winds (a seasonal wind of the Indian Ocean and South Asia) that blow from the southwest from June to September. These winds encounter the heights of Dhofar's mountains, namely Jabal Samhan in the east (1678 meters), Jabal Al-Qamar in the west (1400 meters) and Jabal al-Gara in the center (1000 meters). During this season the monsoon winds, blowing in the face of these high mountains, form low clouds causing dazzle fog conditions and rain. In this period, the average annual precipitation is estimated to be 200-500 mm in the mountains and 110 mm in the coastal plains, and humidity ranges between 80% - 100%. Consequently, temperature drops and marks a maximum average of 32C. This seasonal monsoon and tropical climate in Dhofar has created characteristic ecological conditions. The fogs carried by the wind revitalize luxuriant vegetation and dense woodland. Therefore, climatic conditions in the mountains are characterized by a long dry season (winter and summer) followed by a season of heavy rainfall (khareef: rainy season). The trees in the mountains usually shed their leaves during the dry season and develop leaves at the start of the rainy season. This monsoon climate and temperate vegetation have qualified Dhofar to be an attractive region within Arabia as a whole.

The ecology of Dhofar has been marked by a landscape dominated by a series of three mountain ranges, namely Jabal al-Gara, Jabal al Qamar and Jabal Samhan. The range of these mountains constitutes significant characteristics of Dhofar's ecology. Among the three mountains, Jabal al-Gara presents the most diversified ecology. Six ecological zones have been identified (cf. Miller and Morris 1988; Ghazanfar 1992; Hag Bahit [n. d.] in ElMahi



Symbols	6	5	4	3	2	1
Ecological Zones	Steep valley & minor hill sides (desert)	Undulating plateau & upper wadi catchment (quatan)	Higher slopes & deeply incised Undulating plateau (khatam)	Escarpment steep slopes and wadis	Coastal plain foothills, wadis, and plains	Coastal line
Soil Types	Lithosols, colluvial Rock slopes Minimal soil development	Non to slightiy Cracking clay soils Over rocky subsoil	Shallow & rocky cracking to noncracking clays	Very shallow & rocky red soil	Silty, sandy to gravelly alluvial soils	Unconsolidated marline & aeolian sands
Vegetation Types	Short annual Grass- low Shrubland	Short annual grass dwrf shrubland	Open grassland with scattered trees & steep wooded wadis	Woodland	Minimal shrubs & sparse forbs & grass cover	Low subshrul & grass cover
Erosion Types	Water & wind	Wind	Water	Water	Wind & Water	Flooding & wind

Fig. 2: Six ecological zones of jabal Qara.

Table 1: Jabal al-Gara Ecological Zones

Zone	Name of the zone	Characteristic plants species
1	The plains	Low sub-shrub and grass cover
2	Foothills	Minimal shrubs, sparse forbs and grass cover
3	The escarpment	Woodland
4	al-Khatum	Open grassland, scattered trees and steep wooded wadis
5	al-Qatan	Short annual grass and dwarf shrubs
6	al-Nejad	Desert and short annual grass- low shrub land

2001:134). The six ecological zones in (Fig.2) are described in the following Table 1.

The flora and conditions in these six ecological zones are described by Miller and Morris (1988: xiii-xiv) (cf. Fig. 2). The following is a summary of them (cf. Miller and Morris ibid.):

The plain: zone 1

This zone lies between the sea line and the foothills (Fig. 2). Two main features characterize it: lagoons and plains. The lagoons are dominated by *Avicennia marina*. The plains are clearly bare land, though water courses that dissect it are well vegetated with plant and shrub species. Scattered trees and shrubs include *Acacia tortilis, Zizihus teucadermis, Tamarix aphylla, Cadaba baccarinii, Cadaba farinose, Commiphora spp., Caesalpinia erianthera, Adenium abesum, Euphorbia spp., Aloe dhofarense,* and *Aloe inermis*.

Foothills: zone 2

The foothills run along the base of the escarpment (cf. Fig. 2). It is very much characterized by termite mounds. Trees such as *Boscia arabica* are common and shrubs including *Commiphora* spp., *Grewia spp., Croton confertus* and *Jatropha dhofarica*.

Escarpment woods and grasslands: zone 3

This distinct zone follows the foothills. It is divided into other minor zones which can be summarized as follows:

(a) This zone is known locally as "fimot". It is characterized by the sheltered seaward slopes.

(b) "khashem" is the local name for the wooded southern slopes, steep-sided valleys and the rolling summit grasslands.

(c) The lower woodlands bushes are common including *Acacia Senegal, Commiphora spp., Maytenus dhofarensis, Croton confertus* and *Blepharispermum hirtum*.

(d) The open slopes include trees such as Delonix elata, Anogeissus dhofarica, and *Sterecutia africana lanea* sp. *In addition, climbers such are Cissus quadrangularis* are common.

(e) Dense woods characterize the valleys, which are dominated by trees of *Ficus* spp.

(f) The lower parts of the valleys are dominated by *Ziziphus-spina-christi* and *Acacia nilotica trees*.

al-Khatum: zone 4

This zone lies further from the sea and thus the effect of the fog carried by the monsoon winds is less (cf. Fig. 2). al-Khatum is the dry plateau with fewer trees and shorter grass. *Olea, Anogeissus* and *Dodonaea* are to become noticeably less common giving way to this dwarf shrub land. *Euphorbia balsamifera* and

Commiphora spp. are dominant in this zone.

al-Qatan: zone 5

Miller and Morris (ibid.) described this zone as north draining wadis and cliffs. Its location is more distant from the effect of the fog carried by the sea winds (cf. Fig. 2). As a result, the grassland becomes thinner and the wadis drain northwards. The most common trees are *Acacia etbalica, Dracaena serrulata* and *Commiphora serrulata*.

al-Nejad: zone 6

This desert plain is characterized by small rocky hills and gravels. *Boswellia sacra, Acacia etbalica* and *Nannorrhops ritchieana* are scattered across the plain (cf. Fig. 2).

However, it is worth mentioning that there is no sharp demarcation between these zones. In a personal communication, Salah Ageib (2007) suggests that their boundaries are basically identified by their flora, which is why the boundaries between them merge in many areas of the Dhofar Mountains.

The Archaeology

In Dhofar, the archaeological evidence clearly attests to human occupation as early as the Stone Age (cf. Zarins 2001). Zarins (2001: 26) links the proposed four southwestern high monsoonal patterns that extended between 9000 BP and 329.000 BP by Clemens and Prell et al. (1991:723) to the Stone Age of Dhofar. His (ibid.) suggestion connects the period of the four southwestern monsoonal climatic phenomena to man's technical advancement. It is summarized in the following table:

The findings described by Zarins (2001) in Dhofar can be summarized in the following sequence. The Lower Palaeolithic (one million years -2000,000 BP) is represented by Early Acheulean handaxes at Hanun (cf. Villiers-Petocz 1989 and Zarins 2001) An Acheulean site near Matafah on Wadi Ghadun is reported to be the oldest in Dhofar (cf. Zarins 2001:33). As for the Middle Palaeolithic (200,000-100,000 BP), no sites have been reported (cf. Zarins 2001:33). However, sites and tools are reported from the area of Shisur and attributed to the Upper Palaeolithic (ca. 100,000-70,000 BP) (cf. Zarins 2001:34).

The Neolithic has also been witnessed in Dhofar (cf. Zarins 2001 and 2002). In the meantime, the Neolithic chronology of the region of Eastern Arabia, Oman and Rubal-Khali, has been defined by three distinct periods. The estimated dates of the three Neolithic periods can be summarized as follows: Period I 6500-5000 BC, Period II 5000-3800 BC, and Period III 2300 BC. (cf. Zarins 2002:415).

Cremaschi and Negrino (2002:333-363) report Palaeolithic finds, Neolithic flint quarries, trapping stones and Neolithic hunting sites in Al-Nejed. In the southern parts of Jabal Al-Gara, caves and Epipalaeolithic sites are found.

Zarins (2001:34) suggests that the Neolithic occupation of Dhofar was facilitated by the summer monsoon some time after ca. 10,000BC. Several sites and different materials were reported from the area of Shisur. Other

Table 2: Climatic Phenomena and Stone Age Technology

First highest southwestern monsoonal	329.000BP	Lower Palaeolithic
Second highest southwestern monsoonal	261.000 BP	Middle Palaeolithic
Third highest southwestern monsoonal	215.00BP	Upper Palaeolithic
Fourth highest southwestern monsoonal	9000 BP	Neolithic

sites have also been reported in Hailat Araka, Mudai, and Andhur. Structural remains, believed to be Neolithic, have been reported from Ayun, Wadi Dhahabun, Dauqa and Hailat Araqa sites. These structures were circular houses and consist of units. At Matafah around twenty sites are reported to have circular house structures. Excavated material from these sites has proved to consist of shells, bones and stone tools. In addition, individual human burials with grave goods (shell beads) are reported from Matafah. Occupational sites are also reported from the Zebrit area. Neolithic quarry sites are also reported from Andhur, Hanun, Matafah and Mirbat. (cf. Zarins 2001:35-7). Close to the sea, Neolithic material is also encountered in the terraces of Sahalh and Ain Humran. Interestingly, Zarins (2001:48) states categorically that no evidence of Neolithic sites or material was encountered in upland areas. Furthermore, radio-carbon dates for the Neolithic in Dhofar are: (9280 + 210 BP, 5820 + 140 BP and 4760 + 80 BP and 4910 + 70 BP). These correspond to the previously mentioned three Neolithic Periods (cf. Zarins 2002:417-418).

The contemporary pastoral groups of Dhofar

In the southern parts of Arabia, pastoralism must have evolved under appropriate ecological conditions that allowed its survival. The history of the introduction of domesticates (cattle, goats and camels) into this region remains unclear. Nevertheless, the climatic changes brought by the Holocene ca. 10000 BC must have played a significant role in the gradual development, or even the introduction, of Neolithic pastoral groups in this part of Arabia. Characteristic human adaptation and cultural ecology must have been shaped in response to such conditions in this part of Oman.

Today, the Dhofari pastoral groups exploit almost the six ecological zones mentioned above. Their principal animals are cattle, camels and goats. However, the pastoralists can be divided into three groups according to the principal animal of each group: cattle herders, camel herders and goat herders. The requirements of each animal (pasture, water, etc.), resource seasonality and ecological conditions dictate their distribution. Consequently, their pastoral adaptation is shaped by these and other factors. Transhumant seasonal and cyclic movements are adopted and geared towards the different seasons and animal requirements. As a result, animals are moved to different localities in winter and in rainy seasons (khareef). The following tables (3a and 3b) summarize the animals' movements in response to season and location:

A major impetus for seasonal movements by the camel and goat herders is to avoid hematophagous flies. Informants confirm that camels and goats are moved seasonally in the khareef to avoid wet conditions and these flies. Cattle are principally in al-Khatum and al-Qatan zones during rainy seasons. Few family herders move their cattle from one zone to another. This is understandable because the natural range of these hematophagous flies is limited to the foothills, the escarpment woods, al-Khatum and al-Qatan zones. Therefore, cattle are the only animals that encounter the hematophagous flies.

The hematophagous flies

Parasitism has been a focal point in worldwide scientific investigations. Up to the present, it remains a decisive health issue and receives great attention in research circles. As regards this question, as Bates (1964:83) puts it:

> "Man has been able to cope with the big things easily, but the little things that feed on him have continued to flourish".

Table 3a: Animal Movements in Winter/Summer

Season	animal	Area of distribution North and South of Jabal Gara
Winter/summer	cattle	Al-Khatum and al-Qatan
Winter/summer	camels	Foothills and al-Qatan
Winter/summer	goats	Foothills and escarpments

Table 3b: Animal Movements in Khareef

Season	animal	Area of distribution North and South of Jabal Gara
Khareef	cattle	Al-Qatan, Al-Khatum, Foothills and occasionally coastal plains
Khareef	camels	coastal plains and al-Nejad
Khareef	goats	Foothills, coastal plains and al-Nejad

In Dhofar, pastoral groups identify three flies as disquieting and distressing elements in their environment. The flies are blood-feeding: *Lyperosia minuta, Musca crassirostris* and *Forcipomyia lasiohelea*. They all belong to the order Diptera and are known locally, as in the order above, as the "black fly", "kieszet", and "arnut". They are small haematophagous insects and feed on vertebrates' blood.

Blood-sucking insects are common in aquatic or semi-aquatic habitats throughout the world. In Dhofar *L. minuta, M. crassirostris* and *F. lasiohelea* appear seasonally during the monsoonal rains in July-September. They are terrestrial and their occurrence is seasonal and confined to certain zones. Officials in the Ministry of Agriculture, as well as the Dhofari pastoralists themselves report that these flies are diurnal and thus active only during the day. Their bites can cause overt and circular lesions on the animals. In spite of their perilous nature, they have not been scientifically investigated in Dhofar, and the only available study was carried out by Mellor (1978) in the 1970s. Nonetheless, the current study has recorded the range of hematophagous flies in Dhofar in response to the different ecological zones mentioned above. Their natural range is mapped in the foothills, escarpment, al-Khatum and al-Qatan during the rainy seasons (Fig. 3).

Lyperosia minuta

The "black fly," *Lyperosia minuta*, is common in tropical and subtropical habitats. Quoting work by (Zumpt 1973) in addition to field observations in Dhofar, Mellor (1978: 168) reports the following:

> "… little is known of the biology of *L. minuta* but flies of this genus lay their eggs in fresh cattle (or buffalo) dung and mature larvae pupate in the damp soil under the dung. The whole life cycle from egg to adult takes only 8-9 days at 26-32 C. This is almost the case with *L. minuta*, since

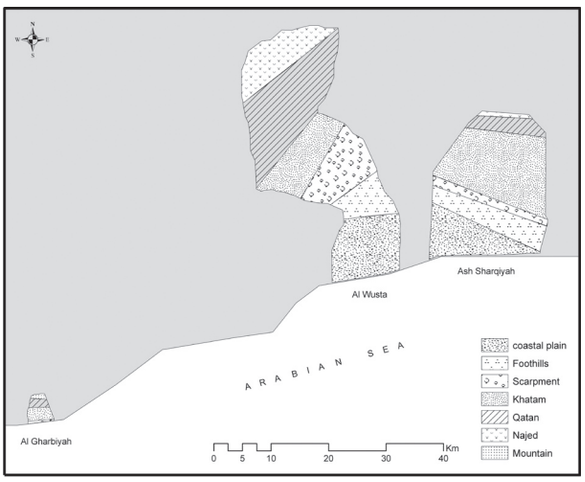


Fig. **3: The natural range of hematophagous flies in Dhofar.**

> I found several pupae resembling those of *Lyperosia* beneath pats of dung and I frequently saw *Lyperosia* adults leave cattle to alight on freshly deposited dung presumably to oviposit. This observation could easily be conformed by breeding out adults from pats of cattle dung".

In Dhofar, these flies use pats of cattle dung to oviposit. The life span of *L. minuta* ranges between 10 days to several weeks and the pupae remain through winter under the pats of cattle dung (Mellor 1978: 168). Finally, an interesting field observation is made by Mellor (ibid.); he says the flies (*L. minuta* and *M. crassirostris*) prefer dark coloured animals. They were observed on the affected animals' shoulders, front legs, heads and withers.

Musca crassirostris

This fly, "kieszet", is known to feed via hematophagy. Veer et al. (2002: 502-3) describe *Musca crassirostris* as follows:

> "Adult fly 4.5-6.5mm long, with ash-grey body colour, and stout proboscis with prestomal teeth which are used for scratching the sore skin so that blood flows more freely. It is a common blood feeding species …".

Patton (1992:423) studied *Musca crassirostris* in India and described it as a "cattle fly", being one of the major cattle pests in the Indian environment. He (ibid.) reported that it is capable of inflicting vicious bites on livestock. As a result, it materially reduces the milk quantity of Indian milk cows.

In August 1977, Mellor (1978: 167) visited Dhofar and examined the (Khareef) hematophagous flies. He (ibid.) reported that *Musca crassirostris* is more robust and larger than *Lyperosia minuta*. For this reason it does not disappear in windy weather. He reports that both flies, *L. minuta* and *M. crassirostris*, use cattle dung in which to lay their eggs. It has also been reported that the larvae use the damp soil under the dung to pupate (cf. Mellor 1978: 168). *M. crassirostris* are also bovid dung breeders and have a similar life cycle to *Lyperosia* spp. (ibid.).

Informants report that these flies are usually found in the proximity of the animals. In the field, they are observed close to cattle enclosures during the day. Again, it was possible to document these flies on fresh cattle dung pats.

Forcipomyia lasiohelea

This is a biting midge and has both anterior and posterior prolegs. They are also present on larvae. Larvae are both terrestrial and aquatic and feed primarily on algae and fungi (cf. http://en.wikipedia.org/wiki/ Forcipomyiinae 2.7.2008). Yi-Yuan Chuang et al. (1998:205-209) studied *Forcipomyia taiwana* in the Nantou Area in Taiwan and pointed out a correlation between the abundance of this species, rainfall and temperature. In Australia, Bellis et al. (2004: 324-328) studied *Forcipomyia* in the field and concluded that it was only active during the day.

In Dhofar, the influence of these flies is broad and profound. It is a significant element in the ecology of all vertebrates, pastoralists' adaptation and way of life. In essence, they are a true ecological limiting factor in the ecosystem. They are adapted to sucking vertebrate blood and their bites cause an allergic response in man and animal. Their larvae are always found in a damp location. Therefore, it is not surprising if they are found in Dhofar cattle pats.

The pastoralists' adjustment to hematophagous flies

Traditional cattle pastoralists in the al-Khatum and close to the escarpment zones have

reacted to the effect of these hematophagous flies by taking certain measures to protect their animals. In the Dhofar Mountains, all cattle pastoral groups use the same measures against the hematophagous flies. Informants confirm that these current measures were also used by their ancestors.

The first of these measures is the animal enclosure. This is built in a way that protects the animals. It has a rounded shape and is built of stones and wood and covered by heavy grass (Fig. 4). The door is usually made of wood and covered with black cloth. The entrance is not straight, but zigzags in order to break light beams. The purpose of this design is to keep animals inside a dark enclosure during the day, when the hematophagous flies cannot be active (Fig. 5). It is, therefore, clear that these people had no other alternative, but to keep their animals for the whole day inside such enclosures. Elderly informants reported that caves were used to house the animals in the early days. Some pastoral families took refuge in caves during rainy seasons for protection against the winds, predators and flies. Caves must have offered a controllable physical space during the day. In fact, informants confirm that caves were good and safe refuges for the animals and their owners during the wet season.

Fig. **4: The cattle enclosure is built of stones, wood and covered by heavy grass.**

Fig. **5: The cattle enclosures are kept pitch-dark.**

Knowing the flies' seasonal threat, herders take a second step to protect their animals. They change the timing of graze during the rainy seasons and, as an alternative, animals graze during the night. This has proved to be a successful substitute since hematophagous flies are diurnal. The animal owners know that the flies are diurnal and thus night grazing has become a central activity in their animal management. Before sunrise all animals return to the pitch-dark enclosures for a fly-free day. It is interesting to notice that pastoral groups under this ecological stress have forced diurnal animals to be nocturnal.

Elderly informants also call attention to the fact that night grazing was also perilous. Predators such as wolves and hyenas can inflect serious injury on the animals. Indeed they usually attack more than one animal thus causing considerable damage to the herd.

Third, since grazing commences only at night during the rainy season, the enclosures are also prepared with certain protective measure against the flies. Informants report that flies avoid smoke since it repels them. Therefore, people use smoke as a repellent in the animal enclosures during the daytime. Mohamed Said Ali Safrar from Wadi Ain (al-Khatum zone) is an experienced cattle owner. He points out that cattle enclosures must be cleaned daily and that

Fig. **6: The dry cattle dung (Aszyt) is used as 'bedding' in the animal enclosures.**

cattle dung in these enclosures is collected and kept in a dry place. Once dried, it is divided into two proportions.

One proportion of the dry cattle dung is turned over and over, churned and beaten. This turns the dry dung into a rough ashy substance. The enclosures are swept clean and then the substance is spread on the ground. This is known locally as (Aszyt) (Fig. 6). In other words, the dry dung is used as a bedding material in the enclosures. It dries out the wetness caused by cattle urine and wet dung. The desiccated cattle waste is then easily swept and collected by the herder. Informants justify this treatment by saying that after the animals are taken out for grazing in the night the enclosure's ground is usually wet and littered with fresh dung. This condition can attract the flies. Secondly, they suggest that if they keep removing the wet earth from the enclosure, this can imbalance and disturb the evenness of enclosure's ground. Therefore, using dry dung as bedding in the enclosure is a practical measure that protects the animals and eases the cattle owner's labour.

The other proportion of the cattle dung is left to dry in its original shape. This is known by pastoralists as (Ku). It is set to burn for the whole in one of the enclosure's corners named locally (meer). The dry cattle dung is allowed to burn slowly and eventually the smoke drives away the flies. The animal owner watches over the burning dung, allowing it to burn slowly throughout the day. Elderly informants report that even those pastoral families who in the past took refuge in caves during the rainy seasons followed during the day the same procedures to drive away the flies.

As mentioned previously, these flies oviposit on cattle dung pats and the larvae are always found in such damp locations. Therefore, by drying and burning dung, Dhofari pastoralists are limiting the larvae of these flies in the immediate vicinity of the animals and depriving them of a suitable environment for oviposition.

Fourth, Dhofari pastoralists wear a cloth material called (kirga or sbagah) (Fig. 7). This cloth is worn by men and women, especially during rainy seasons. When pastoralist men and women wrap themselves in it, the dye can be clearly seen on their bodies. It consists

Fig. **7: The (kirga) is worn by Dhofari cattle pastoralists during rainy seasons.**

of two parts: one part is to wrap around the shoulders and the second part for the lower part of the body. Elderly informants confirm that this material (kirga or sbagah) is nontoxic and dyed "ultramarine-blue". The pigment is sodium alumino-sulphosilicate. It is also known to have the advantages of a clean and bright reddish blue shade when compared with different blue pigments and dyes (Fig. 8). (cf. http://hugeroc.com.cn/news1.asp?ArticleID=323&gclid=CO_N9quC25cCFQ9WtAodjANADQ).

Baker (2004) describes ultramarine in the following:

> "Ultramarine is famous for having been the most expensive pigment. It was more expensive than gold during the Renaissance and also highly exotic because of its origin. First used in 6th century Afghanistan, the pigment was used most extensively in 14th and 15th century illuminated manuscripts and Italian panel paintings. …The pigment is made from the precious stone lapis lazuli. The stone was also used as a medieval cure for melancholy. The source of the mineral in the Middle Ages was from the Badakshan mines in Afghanistan. Even the best lapis lazuli has impurities of calcspar and iron pyrites".

Elderly informants insist that the colouring in the cloth is medicine and that it is good for their health. This general assessment cannot be tested; however, insects react to certain colours, and this reaction should be briefly explored here.

It is known that flies' movements depend on stimulus gradients which can be chemical, sound, or light. Moreover, their behavioural actions are dependent on certain stimuli such as colours that are bright or dark (cf. Laarman 1955 and 1958).

Fig. **8: The (kirga) is dyed by pigment ultramarine - blue.**

Galati et al. (2001:641-647) discussed the external stimuli of host-seeking, blood feeding, and subsequent rest among the biting flies. The actions of external stimuli are explained as follows:

> The external stimuli consist of visual, physical and chemical cues. The visual cues stimulating the orientation of flies to a host include reflection of light, movement, contrasting actions, size and shape. Among physical cues are included radiant and convective heat, moisture, sound and surface structure and among the chemical ones, carbon dioxide and components of odour (Laarman 1955, 1958).

Moreover, Galati et al. (2001:641-647) inform us of flies' attraction toward colours and suggest that it is related to surfaces with

a low reflective capacity, while Gjullin (1947) suggests that colours have spectral reflectance that can possibly induce mosquitoes. Again, the issue of visual stimuli among various insects and how differently they can respond has not been completely concluded.

While the issue of insects' stimuli remains to be uncertain, the concluding remark made by Sippel & Brown (1953) and quoted by Galati et al. (2001:641-647) is manifest and deserves attention :

> "…a particular behavioural response is common to different species."

Consequently, ultramarine blue must have an effect on the diurnal hematophagous flies in Dhofar. All informants confirm that pastoralists in the past used to wear kirga or sbagah all the year round, especially during the rainy seasons. However, the main point is that it is rainy season wear. The dyed kirga or sbagah leaves a dark pigment and traces on the bodies of the pastoralists. The implication of wearing this dyed cloth and the timing specify its advantage. During rainy seasons it must repel these diurnal flies. Experience must have taught the pastoralists that dark colours or darkness repel the blood-sucking flies. For the same reason they have switched the animals' grazing activity to night-time, but during the day the animals are kept in completely dark enclosures.

Fifth, informants such Eeisa Al Mamari from Shab Suab and others have pointed out a certain plant species that acts as a repellent to blood-sucking flies; namely, the 'arnut" *Forcipomyia lasiohelea*. The plant with a repellent effect on this fly is *Becium dhofarense* (Fig. 9) and is known locally as (hodem) (Personal communication with Salah Ageib 2007). Moreover, they report that when a person rubs his/her body with the green leaves of this plant, the flies do not bite him for some time.

Fig. 9: The plant *Becium dhofarense* **is used as a repellent to blood - stucking flies.**

Miller and Morris (1988: 152) describe the use of the same plant *Becium dhofarense* as follows:

> "Leaves were rubbed on the site of bites from the tiny biting flies [Jabali: arnut, xanyut] that are the bane of the wooded areas in particular during the late monsoon and early post-monsoon *serb* seasons".

Moreover, Miller and Morris (1988:92) report another plant species *Capparis cartilaginea*, which is used in Dhofar as a treatment for tick bites. It is noteworthy that Miller and Morris (1988) have reported these plant species as herbal treatments for bites and not as repellents for hematophagous flies. Informants claim that (hodem) *Becium dhofarense* (cf. Fig. 9) is used as a blood-feeding fly repellent.

In Dhofar, differences in pastoral group adaptation are mainly dictated by two factors: the principal animal's ecological requirements and the habitat's ecological limitations. The principal animal represents the pastoral group's wealth and their means of survival; therefore, any adjustment must provide for the animals' security and welfare. On the other hand, ecological limiting factors in any ecosystem cannot be removed by a pastoral group. These realities mark the beginning of shaping the

group's adaptation, especially if it is dependent on exploiting natural resources (pasture) through the agency of another species (cattle, camels or goats).

In this context, it is logical to examine the precautionary measures taken by Dhofari camel herders and goat herders. This will cast light on the adaptation of these two groups and make possible a comparison with cattle herders' arrangements in evading hematophagous flies.

It is evident that traditional camel herder adaptation is different from that of cattle herders. The success of the principal animal (camels) requires a certain habitat with unmistakable characteristics. For that reason, camel herders have adopted a different set of precautionary measures against the flies. They are clearly aware of the hazard these flies can pose for their animals during rainy seasons and therefore camels are moved to different locations. They have adopted a system of seasonal transhumant movements. In essence, they avoid rainy seasons in particular locations which are usually within their tribal territory in al-Qatan and on the coastal plains. Hence, they are far beyond the range of hematophagous flies. Another reason for moving camels to particular locations is that camels are not tolerant of rainy and wet conditions. They can easily slip in muddy ground and break their legs. Therefore, owners avoid wet hilly ground.

In summer and winter camel pastoralists move their animals towards escarpments and the al-Khatum. Sometimes, the ground is not muddy and there is no rain. However, crucially, there are no hematophagous flies in these locations at this time of the year. Traditional camel pastoralists in this region of Oman are aware of the limitations of their animals and habitat and their adjustment is a clear response to such ecological limitations.

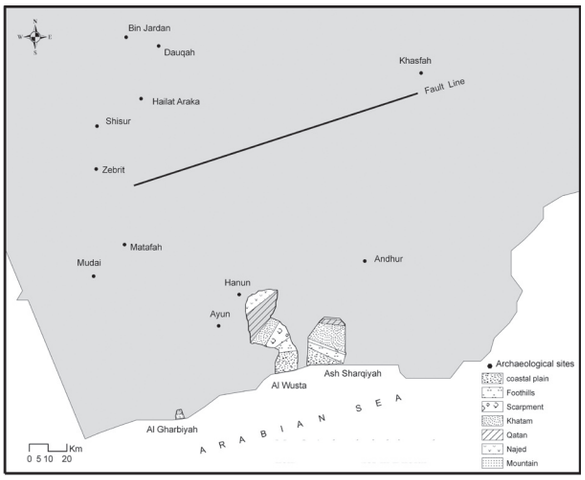


Fig. **10: Distribution of archaeological sites in relation to the habitat of hematophagous flies.**

Again, traditional goat herders present a different response to the hazards posed by hematophagous flies in Dhofar. They adopt a transhumant seasonal movement geared to the potential of the seasons and their animals' vulnerability to hematophagous flies and climatic conditions. They move during rainy seasons to areas not infested by hematophagous flies. These areas are usually not within the torrential monsoon rain zone. It is known that goats are extremely vulnerable to rains and wet conditions. A goat herder like Mohamed bin Bakhit Al-Hilali confirms that his herd's daily movement is to avoid areas infested by such flies. He points out that, although there is good pasture ahead, his goats dare not venture there. He also draws attention to the distribution of his goats (Fig. 11) in a line on the horizon, showing that animals are aware of certain areas marking the beginning of the fly zone. He confirms that the goats dare not go beyond that line (cf. Fig. 11). Moreover, he insists that every goat herder knows the areas occupied by the flies. Herders and their animals avoid these areas completely even though these have better pastures.

Discussion

The study of Dhofari cattle pastoralists'

adjustment to hematophagous flies reveals certain precautionary measures. These are an adaptation to an ecological limiting factor. They are the result of accumulated pastoralist empirical knowledge and experience in this specific biotope and its conditions. They are designed to adjust and improve means of adaptation in order to make the pastoralists' existence possible and guarantee maintenance. Thus they are to improve chances of survival for man and his animals. No doubt, these precautionary measures involved a gradual adjustment in the pastoralists' ways and methods to conform to the prevailing ecological conditions.

Now, to what extent can this traditional acclimatization verify a plausible analogy with early pastoral practice? And can it furnish an understanding of prehistoric pastoralist adaptation to this part of Dhofar? Because of their importance to the attempted analogy and confirmation, it would be useful to cast light upon certain aspects before proceeding with this attempt.

Elderly informants stress over and over that these measures were designed by their ancestors. They claim that the measures have always been in use and have proved their usefulness. Although the measures seem to be old, their actual date is not clear. The fact remains that it is not known exactly when these measures actually evolved and came into use. Nonetheless, they can perhaps be prehistoric, except for the use of kirga or sbagah, which is dyed ultramarine-blue. This particular precautionary measure

Fig. **11: Goats in a line on the horizon away from the flies' zone.**

using this pigment cannot be attributed to any of the prehistoric stages such as the Stone Age (Neolithic), the Bronze, or the Iron Age. The fact that this pigment was first used in the sixth century AD (Afghanistan) and then extensively in the fourteenth and fifteenth centuries (cf. Baker 2004) suggests its introduction into Dhofar at some time in the fourteenth or fifteenth centuries AD. However, evidently these measures must have evolved some time after pastoral groups entered the areas infested by hematophagous flies and started to settle in this area for the duration of the rainy season.

In Dhofar, archaeological sites are reported in various parts of this region. Consequently, by looking at the distribution of these sites (Fig. 10), it becomes obvious that none of them is within the present hematophagous flies' natural range (foothills, escarpment, al-Khatum and al-Qatan). Therefore, the sites' geographical distribution points out that man did not occupy this area at any stage in prehistoric times. However, Ahmed Matoug Al-Malgwi Al-Shahri, an elderly informant (camel herder) and others stress that up to 1960s the plains were also infested by the flies during the rainy season. Consequently, they were forced to move their camels as far as the coastal plain to avoid the flies during the rainy season.

The possibility that these flies had a much wider natural range in prehistoric Dhofar cannot be excluded. Therefore, the distribution of the archaeological sites in relation to the present hematophagous flies' natural range (foothills, escarpment, al-Khatum and al-Qatan) can also be explained. The areas in question must have been heavily wooded to the extent that it precluded pastoralists from pasturing their animals in such conditions. Moreover, thick vegetation can become hazardous for both man and livestock. Consequently, being densely wooded and infested by such hematophagous flies makes such an area extremely unfavourable for pastoralists.

Indeed, it is not known when man first occupied this area (foothills, escarpment, al-Khatum and al-Qatan). Up to the present, no archaeological sites have been reported from these ecological zones. In fact, the geographical distribution of the prehistoric sites is mainly confined to al-Nejad area (cf. Fig. 10). This ecological zone is not affected directly by the monsoon winds and hence does not constitute a suitable habitat for hematophagous flies such as *Lyperosia* minuta, *Musca crassirostris* and *Forcipomyia lasiohelea*.

On the other hand, there are certain facts that need to be considered at this point. To begin with, the absence of archaeological evidence can perhaps be explained by the fact that pastoral groups possess very few material possessions. Moreover, it is unmistakable that they usually leave behind very little material evidence. On the other hand, Dhofari pastoral groups are known to adopt transhumant seasonal and cyclic movements, which indicate that there are no permanent settlements (cf. ElMahi forthcoming 2). It is quite possible that the area in question was only visited during summer and winter, but was completely avoided during the rainy seasons.

Secondly, rock scenes depicting pastoral activities are common in several caves and rock shelters in Dhofar. Among these scenes, cattle are prominently depicted. However, dating rock drawing is problematic; these rock scenes can perhaps be attributed to any period in the history of Dhofar. Otherwise, these caves were visited in winter and summer and during the Khareef season in order to avoid the flies.

If this inference is correct, then there must be factors that made pastoral groups later in the history of Dhofar (perhaps some time after the

Late Iron Age) occupy the different ecological zones mentioned above. But what was it that made some pastoral groups venture into the hematophagous flies natural range? Was it the growing numbers of pastoral group the forced some to move into such areas? Of course, this question and others cannot be answered without further meticulous archaeological investigation of these parts of Dhofar.

In conclusion, the complete absence of archaeological evidence in this part of Dhofar makes it possible to conclude that the flies' range was not occupied by man in prehistoric times. On the one hand, prehistoric hunters-gathers would have found it difficult to survive in a habitat infested by hematophagous flies. On the other hand, the situation would have been inconceivable for Neolithic pastoralists without such protective measures. Nonetheless, the precautionary measures taken by traditional pastoral groups in Dhofar are no doubt an essential part of their adaptation to the environmental conditions. It is irrefutable that these measures must have evolved with the beginning of the pastoral groups' occupation of habitats invested by hematophagous flies. The emergence of pastoral culture and its adaptation requirements in this particular ecoregion require further attention and investigation.

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ملخص: يتناول هذا البحث نتائج دراسة ميدانية «أثنواركيولوجيا» للوسائل الاحترازية التقليدية التي تمارسها مجتمعات الرعي للحد من الحشرات مصاصة الدماء في إقليم ظفار بعمان. وتعمل هذه الدراسة على توثيق جميع هذه الوسائل التقليدية. كما تسعى الدراسة لفهم ممارسات الحاضر لفهم ممارسات الماضي التي لا تترك لنا أثرا أو دليلا ماديا في محتوى المواقع الآثري. ومن ناحية أخرى، قامت الدراسة بعمل خارطة تحدد الناطق البيئي لتوزيع هذه الحشرات في ظفار، ومقارنتها مع توزيع المواقع الأثرية في هذا الإقليم، بغية إيجاد ارتباط أو تلازم بينهما. ونتج من دراسة هذه الوسائل الاحترازية، وضع تماثل متوازن بين الممارسات المجتمعات التقليدية، وتلك المجتمعات الرعوية التي عاشت في ظفار في فترات ما قبل التاريخ.

Notes

(1) A tsetse fly is a host for the parasite *trypanosome*s. It causes sleeping sickness in humans and transmits the wasting disease nagana to all kinds of domesticates.

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