

## Onchocerciasis in the Arabian Camel (*Camelus dromedarius* L.) in the Central Region (Riyadh and Qasim Provinces) of Saudi Arabia

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ABSTRACT. Skin snipping of the head and neck regions of live Arabian camels (*Camelus dromedarius*) in the Central Region (Riyadh and Qasim Provinces) of Saudi Arabia and the release of *Onchocerca* species microfilariae (mf) into 80% Tyrode's solution with 20% camel serum and antibiotics have been used to estimate the prevalence of camel onchocerciasis in this region. The study has also been complemented by skin snipping of camels to be slaughtered for human consumption at Riyadh Central abattoir and at Buraydah abattoir during *ante-mortem* examination and by *post-mortem* examination of carcasses of the same camels for adult *Onchocerca* worms. *Onchocerca fasciata* is the only species detected with an overall prevalence rate of 59.1% which is corrected to 77.2% by the elimination from the sample of young and old camels that do not have mf in their snips. The prevalence of infection is higher in camels in Qasim Province (65% for all camels sampled and 84.3% when corrected by removing young and old camels with no skin mf) than in those in Riyadh Province (56% and 73.4%, respectively). However, camels in the agricultural parts of both provinces show the highest rate of onchocerciasis and those in the drier western parts of Riyadh Province (Al-Dawadmi and Afif) are the least infected. Sedentary camels in farms have the highest prevalence of infection and the highest density of skin mf than free-ranging nomadic camels. This has been discussed in accordance with the suitability of breeding habitats of supposed vectors (possibly midges of the genus *Culicoides*) in and around farms than anywhere else. Both sexes are equally infected and the infection is chronic, non-seasonal and results in no overt clinical disease, but increases with the age of the animal (older camels are more infected than young ones). *Onchocerca fasciata* has a predilection to the *ligamentum nuchae* where infections seem to start and thereafter, spread to other locations, especially subcutaneously in the regions of the flanks before becoming generalized in old camels. No pathological conditions have been observed in association with mf in the skin of infected camels, but the general host reaction to adult worms consists of non-suppurative worm granuloma formation, but with far less degree of fibrosis and cellular reaction than in any other *Onchocerca* infection.

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The Arabian Camel (*Camelus dromedarius* L.) in Saudi Arabia is known to be infected with *Onchocerca fasciata* Railliet and Henry 1910, this parasite was redescribed and its taxonomic status has been clarified from specimens collected from camels in Asir Province (Bain and Nasher 1981). An infection rate of 34.2% was once recorded from several parts of the country during *post-mortem* examination (Cheema *et al.* 1984) and a higher incidence of 59% was also observed in camels slaughtered for human consumption at Abha abattoir, Asir Province (Nasher 1986). In a preliminary investigation carried out in 1981, the morphology of both uterine and skin microfilariae (mff) of *O. fasciata* was studied and skin mff proved to have a predilection to the ears, head and neck regions. These findings were later confirmed by Cheema *et al.* (1984) and proved to be of great epidemiological significance as they facilitate the investigation of the spread of onchocerciasis in live camels using the skin snip technique (see El Bihari and Hussein 1975, 1976, 1978, El Sammani and Hussein 1983, Atta El Manna *et al.* 1984, Hussein and El Sammani 1985, 1990, and Hussein *et al.* 1988).

In the present study, the skin snip technique has been employed to investigate the spread of onchocerciasis in live camels in the Central Region (Riyadh and Qasim Provinces) of Saudi Arabia. The rate of infection in camels of either sex and various age groups has also been assessed.

### Materials and Methods

Over an 8-year period (1982 - 1990), a total of 1,680 camels of both sexes and various age groups (Table 1) has been surveyed in the localities shown in Fig. 1 for onchocerciasis using the skin snip technique of El Bihari and Hussein (1975, 1976, 1978). Prior to sampling, the area of the skin to be snipped is infiltrated with a 4% aqueous solution of procaine hydrochloride, the action of which was sometimes prolonged by the simultaneous injection of adrenaline as suggested by Hussein and El Sammani (1990). Skin snips were then punched off the locally anaesthetized area using a metallic pincer-like snipper that punches off skin snips each 15 mm in diameter (see Hussein *et al.* 1988). The snips were kept into an icebox and were carried over ice to the laboratory on the day of collection. In the laboratory they were thoroughly washed with soap and water, wiped up with a dry clean linen cloth and then individually weighed in a top-loading balance (AC 1200 D, Denver Instrument Comany, Denver, Colorado, USA). They were then shaved with sharp razor blades and each was then shredded with sharp scissors into screw-capped vials (Bijou Bottles) each containing 5 ml of 80% Tyrode solution containing 20% camel serum together with  $1.0 \mu\text{g ml}^{-1}$  streptomycin sulphate and  $6.3 \mu\text{g ml}^{-1}$  penicillin G (See Hussein and El Sammani 1990). The bottles were then incubated at room temperature ( $25 \pm 2^\circ\text{C}$ ) for at least 2h before the released mff were counted and expressed as mff  $\text{g}^{-1}$  of skin as described by El Sammani and Hussein (1983). Some of the skin snips were digested for 24h in Medium 199 containing  $3 \text{ mg ml}^{-1}$  collagenase and

antibiotics (Schulz-Key 1978) to determine the total number of mff in the snip for comparison with the previous method. Few mff from each snip were fixed, stained and examined as described by El Bihari and Hussein (1976, 1978). Their morphology was determined and compared to that of other skin mff (El Bihari and Hussein 1976, 1978, El Sinnary and Hussein 1981, El Sammani and Hussein 1983, Atta El Mannan *et al.* 1984, Cheema *et al.* 1984, Hussein *et al.* 1988, and Hussein and El Sammani 1990).

The localities sampled were at a radius of 10 km each around each of the urban sites shown in Fig. 1 and had been carefully chosen well away from any mixing between local, indigenous livestock and imported ones. The camels sampled at Qasim Province (except those at Al-Ras), as well as around the cities of Riyadh and Al-Kharj were mainly sedentary animals kept in farms where they were born and bred. Camels examined at Al-Ras or elsewhere, belonged mainly to nomadic, free-ranging herds.

Moreover, 840 and 118 local camels of both sexes and various age groups (Table 2), slaughtered for human consumption at Riyadh Central abattoir and Buraydah abattoir, respectively were also examined *ante-mortem* for onchocerciasis by the skin snip technique and their carcasses were checked for onchocercal nodules using a powerful, battery-operated neon lamp, as suggested by Hussein and El Sammani (1985). Special attention was paid to the subcutaneous connective tissues, the *ligamentum nuchae*, flexor and extensor tendons, suspensory ligaments, splenic ligaments, testes, penis, aorta and brachiocephalic trunks, which are known predilection sites of adult *Onchocerca* worms in animals (Mellor 1973a, Bain *et al.* 1976, 1978, Beveridge *et al.* 1979, Muller 1979, Bain and Nasher 1981, El Sinnary and Hussein 1981, Atta El Mannan *et al.* 1984, Cheema *et al.* 1984, Hussein and El Sammani 1985, 1990, Ferenc 1986, and Hussein *et al.* 1988). During the study, attention has also been paid to afflictions such as blindness, periodic ophthalmia, pruritis and keratosis, as well as to the presence of mff inside camel eyes as carried out by Lagrulet (1962) and by Hussein and El Sammani (1985).

Portions of skin from the head and neck regions were obtained from 120 and 35 camels of various age groups slaughtered at Riyadh Central abattoir and at Buraydah abattoir, respectively. Moreover, onchocercal nodules and adjacent tissues were excised from the carcasses of those animals. In the laboratory, the pieces of skin were washed, shaved, fixed in 10% neutral buffered formalin (10% NBF), sectioned by routine histological methods and examined for detection of mff or any pathological alterations. Some of the excised onchocercal nodules and adjacent tissues were digested in a 7% aqueous collagenase solution in a water bath at 37°C for worm release. The released adult worms were recovered from the digestate under a stereomicroscope and were killed in screw-capped bottles containing hot 70% ethanol. They were then relaxed overnight in the refrigerator before preserving them in 5% glycerine ethanol (i.e. 70% ethanol containing 5% glycerine). Prior to examination, the worms were cleared in temporary wet mounts in phenol-ethanol (80

parts melted phenol crystals in 20 parts absolute ethanol). Some males were mounted in lactophenol (lactic acid crystals 100 g, phenol crystals 100 g, glycerine 200 ml, distilled water 100 ml) or evaporated in glycerine to prevent overclearing of the spicules (see Hussein and Kalantan 1993). The worms were then identified by reference to Johnston (1921), Yamaguti (1961), Muller (1979) and Bain and Nasher (1981). The remaining onchocercal nodules and adjacent tissues were fixed in 10% NBF, sectioned by routine histological methods and were examined for histopathological changes.

## Results

### *Prevalence and intensity of infection*

Numbers of mff  $g^{-1}$  skin obtained in 80% Tyrode's solution with 20% camle serum and antibiotics or in Medium 199 with 3  $mg\ ml^{-1}$  collagenase and antibiotics were comparable. Hence, the first method was used throughout the study due to its quickness in obtaining results. Moreover, the infection rate detected by both methods was the same in male and female camels, but varied with the age of the animal. Therefore, the results are presented with respect to the age of the animal (Tables 1 - 4).

The skin snips of 993 of the 1,680 live Arabian camels sampled over the 8-year period of study carried mff of a single *Onchocerca* species corresponding to the description of *O. fasciata* mff (see Bain and Nasher 1981). However, the total of 21 nodules that were digested in collagenase released 38 complete males and 21 complete females which conform to the description of *O. fasciata* outlined by Bain and Nasher (1981). Hence, the skin snip technique has detected a prevalence rate of 59.1% (Table 1). All of the infected camels were looking healthy and showed no clinical symptoms.

The infection rate was higher in Qasim Province (65%) than in Riyadh Province (56% - Table 1). In both Provinces, however, none of the young live camels (< 1 - 1-year old) was found infected, old live camels (10 - 20 years old) has the lowest rate of infection and 5 - 8-year old camels had the highest (Tables 1 - 3).

The highest infection rate and the highest skin mff density in camels in Qasim Province were found at Riyadh Al-Khubra and Al-Khubra, where most of the camels studied were sedentary in farms. The lowest infection rates and lowest skin mff density in that Province occurred in the free-ranging camels examined at Al-Ras (Table 2). On the other hand, the mostly sedentary camels in Al-Kharj and Hotut Beni Tamim belonged to the group with the highest infection rates and highest skin mff density in Riyadh Province, while the free-ranging camels in Al-Dawadmi and Afif were the least infected and had the lowest skin mff density in the Province. Camles at Al-Zulfi and Shagra, although free-ranging too, showed considerably higher rates of infection and skin mff density than those at Al-Dawadmi and Afif (Table 3).

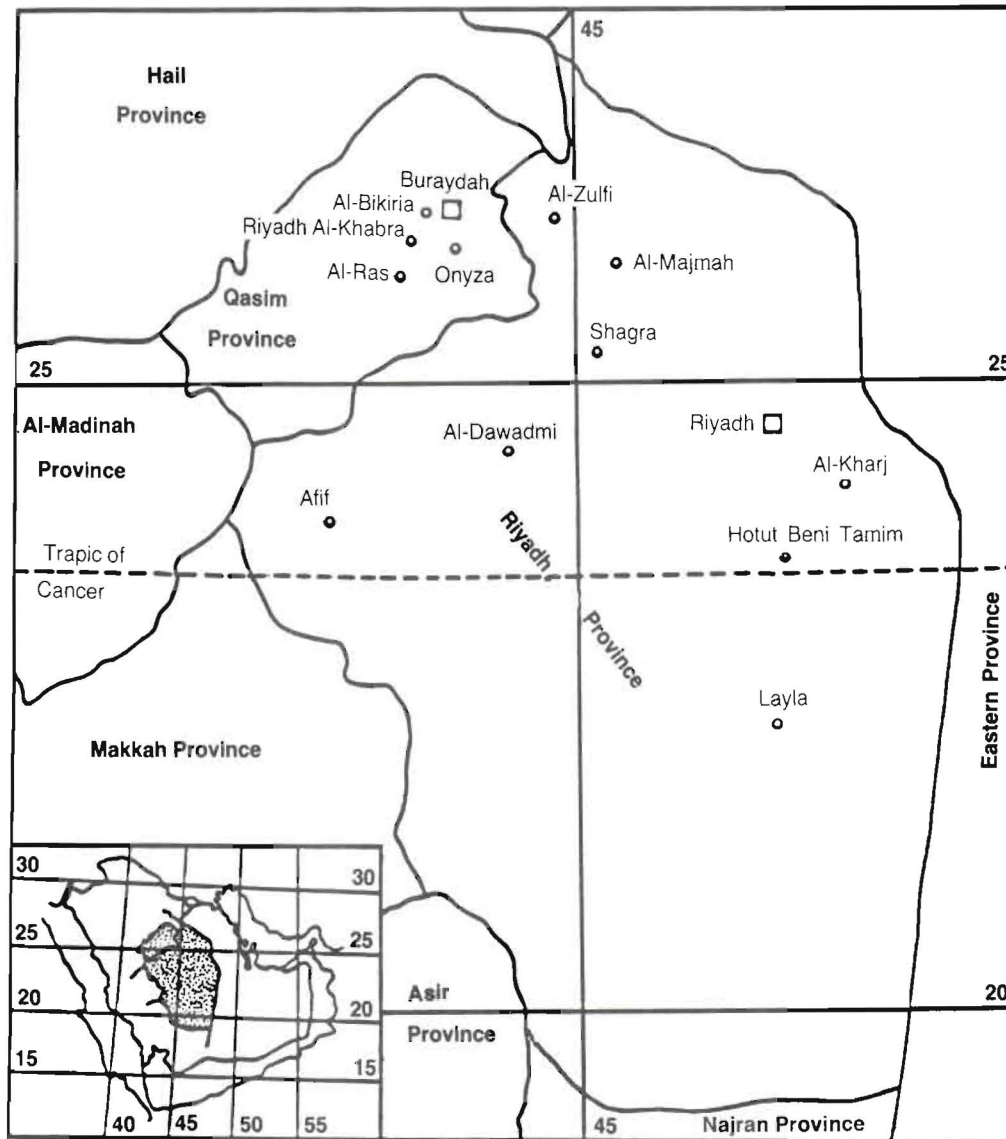


Fig. 1. Map of the Central Region (Riyadh and Qasim Provinces) of Saudi Arabia showing urban centres (all cities in the map) where live Arabian camels have been surveyed by the skin snip technique for onchocerciasis at a radius of 10 km around each centre. Map of Saudi Arabia (inset) showing the location of the Central Region (Shaded area).

The live Arabian camels studied by the skin snip technique during *ante-mortem* examination at Riyadh and Buraydah abattoirs, showed similar rates of onchocerciasis, but those examined at Buraydah abattoir had a higher skin mff density. Likewise, none of the young camels (< 1 - 1-year old) was infected. The eldest were the least infected, and 5 - 8-year old camels showed the highest prevalence (Table 4). On the other hand, some of the young camels (< 1 - 1-year old) were found to be infected during *post-mortem* examination (3 of the 42 at Riyadh abattoir and 4 of the 16 at Buraydah abattoir - Table 4). However, all of these had very small nodules (5 - 10 mm in diameter) being situated exclusively in the *ligamentum nuchae* and each nodule contained a young, non-gravid female worm (i.e. worm without mff in the uterus). Moreover, several of the old camels (10 - 20-year old) that had no mff in their skin snips were found during *post-mortem* examination infested with generalised, old and calcified nodules containing dead and degenerate worms [12 of the 25 (48%) at Riyadh abattoir and 6 of the 12 (50%) at Buraydah abattoir] (Table 4). Very few of such camels occurred in the 2 - 4-year old group of camels (3.2.%) or in that of 5 - 8-year old animals (3.5% - Table 4). The young adult camels (2 - 8-year old) had old nodules in the *ligamentum nuchae*, as well as young nodules containing live worms, mainly subcutaneously in the regions of the flanks.

The presence of several infected camels in the < 1-1-year old group of young animals and many in the 10-20-year group of old camels that have no mff in their skin snips had prompted the removal of these animals from the samples and the prevalence rates were corrected accordingly. Hence, the overall prevalence of infection of 59.1% when corrected as mentioned becomes 77.2%. Subsequently, the rates for Qasim Province are respectively 65% and 84.3%, while 56% and 73.4% are for Riyadh Province (Table 1).

#### *Pathology of the infection*

The skin of the infected camels was smooth and neither thickenings nor acanthosis or hyperkeratosis were observed in the skin of these animals. The mff of *O. fasciata* were scattered throughout the dermis of the skin of infected camels, but no inflammatory reaction was seen around any of them and there was no infiltration by inflammatory cells anywhere in the skin of these camels (Fig. 2).

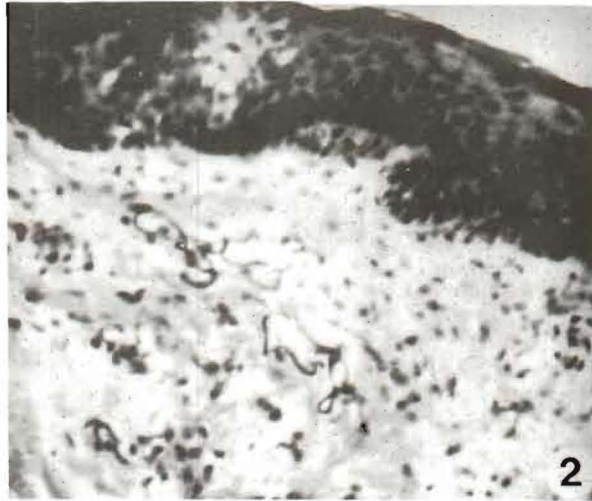
*Onchocerca fasciata* nodules varied in diameter from 5 mm to 75 mm. The smallest nodules occurred in very young camels (< 1 - 1-year old) sampled during *post-mortem* examination in both abattoirs. These nodules were smooth, yellowish to extremely hyperaemic and each contained a young male in the periphery and a non-gravid, young female in the centre. Close to the female worm, there were some haemorrhages together with infiltrations by polymorphonuclear leucocytes and some lymphocytes, but no monocytes occurred in these nodules. Adult camels (5 - 8-year old) had mainly two types of nodules, medium-sized ones about 25 mm in diameter

and larger ones, about 50 mm in diameter. Occasionally some camels had very large nodules of 75 mm in diameter. All of these large nodules were encapsulated by fibrous connective tissues forming the nodular matrix and several cavities containing the intricately enmeshed worms (Figs. 3 and 4). Younger nodules were mostly moderately infiltrated by inflammatory cells, mainly histiocytes, lymphocytes and eosinophils. However, the number of eosinophils decreased gradually as the nodules progressed in age, being replaced by increasing numbers of plasma cells, monocytes and multinucleated giant cells. These nodules contained live worms that were surrounded by sanguineous fluid (Fig. 3). Old nodules were characterized by heavy cellular infiltrations and contained dead or degenerated worms, sometimes together with secondary bacterial infections, heavy fibrosis, coagulative or caseous necrosis and a 'burnt-out' reaction or calcification (Fig. 4), to the extent that local butchers at the abattoirs call these calcified nodules '*hijara*, or stones. Heavy neutrophil infiltration was observed in nodules containing dead or degenerated worms and secondary bacterial infection. Erythrocytes and haemosiderin occurred in some of the nodules. Most of the old nodules (Fig. 4) occurred in the *ligamentum nuchae* of 5 - 8-year old camels which had younger nodules (Fig. 3) mostly subcutaneously in the regions of the flanks. Old camels (10 - 20-year old) had mostly generalized infections with old calcified nodules.

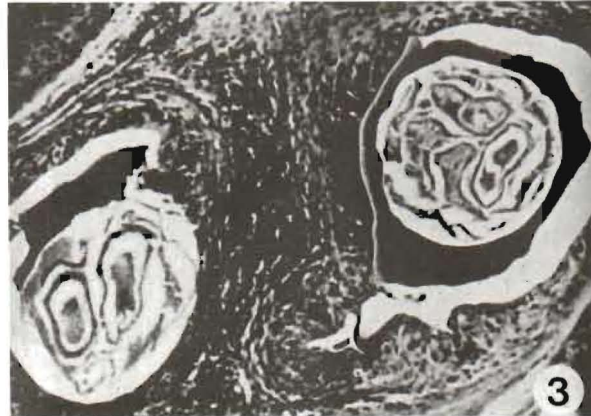
## Discussion

Arabian camels (*C. dromedarius*) in the Central Region of Saudi Arabia were found infected with a single *Onchocerca* species, *O. fasciata*. This is in line with previous observations made elsewhere in the country (Bain and Nasher 1981, Cheema *et al.* 1984, and Nasher 1986). None of the other *Onchocerca* species known to infect camels elsewhere, such as the bovine species, *Onchocerca gibsoni* (Cleland and Johnston, 1910) (Yamaguti 1961), *Onchocerca gutturosa* (Neumann 1910) and *Onchocerca armillata* Railliet and Henry, 1909 (Schillhorn van Veen *et al.* 1978, El Sinnary and Hussein 1981, Hussein *et al.* 1988, and Awad *et al.* 1990) was found infecting Saudi Arabian camels. On the other hand, *O. fasciata* itself is not yet detected in African camels, which were only infected with the bovine *Onchocerca* species, *O. armillata* and *O. gutturosa* (Schillhorn van Veen *et al.* 1978, El Sinnary and Hussein 1981, Hussein *et al.* 1988, Awad *et al.* 1990). The speculations made by Cheema *et al.* (1984) that Somali and Sudanese camels are infected with *O. fasciata* has been strongly refuted by Hussein *et al.* (1988) who are of the opinion that *O. fasciata* is an Asian species and is yet to be reported from Africa. The present results, as well as those of Bain and Nasher (1981) and of Nasher (1986) add support to the speculations of Hussein *et al.* (1988) that *O. fasciata* is an Asian species. Moreover, this is only logical, since, *O. fasciata* was first described by Railliet and Henry (1910) from specimens collected from an Indian camel in Punjab and was later redescribed by Jonston (1921) from specimens collected from a Pakistani camel in Australia and then

2. Photomicrograph of a section through the skin of a 7-year old Arabian camel showing *Onchocerca fasciata* microfilariae in the dermis .



3. Photomicrograph of a section through a relatively young onchocercal nodule in a 5-year old Arabian camel showing moderate cellular infiltration around two cavities containing portions of live female worms surrounded by hyaline material that has resulted from the consolidation of the sanguineous fluid in the cavities due to fixation .



4. Photomicrograph of a section through an old onchocercal nodule in a 15-year old Arabian camel. The nodule is fully laid with fibrous tissues surrounding dead and degenerated worms, together with a "burnet-out" reaction or mineralization of the nodule.



**Figs. 2-4.** Photomicrographs of sections through an infected camel's skin and through onchocercal nodules.



by Henry and Masson (1933) from specimens obtained from a camel of an unknown origin in France, possibly coming from India. Since then, nothing was heard of *O. fasciata* to the extent that its validity as a taxon had been doubted for a considerable period of time (Muller 1979). However, it was only recently reinstated as a valid taxon following its redescription from Saudi Arabian camels in Asir Province by Bain and Nasher (1981).

The present study is the first survey conducted on live Arabian camels in Saudi Arabia to assess the spread of camel onchocerciasis. Previous studies (Cheema *et al.* 1984, and Nasher 1986) were performed exclusively in animals slaughtered for human consumption at abattoirs. However, the present study was made possible by the description and the determination of the predilection sites of *O. fasciata* skin mff from Saudi Arabian camels in our preliminary investigations in 1981, which was later confirmed by Cheema *et al.* (1984). Moreover, the observations of El Sinnary and Hussein (1981) and of Hussein *et al.* (1988) have demonstrated that mff of other *Onchocerca* species infecting camels have the same predilection sites in the skin of the ears, head and neck regions. Hence, any survey of live camels for onchocerciasis should consider sampling those sites by the skin snip technique.

Before the full implementation of the skin snip technique in the present study, the medium in which mff are to be released had to be determined. Hence, digestion in Medium 199 containing collagenase and antibiotics suggested for human onchocerciasis skin snip technique by Schulz-Key (1978) was compared to Tyrode's solution containing serum and antibiotics suggested for equine onchocerciasis by Hussein and El Sammani (1990) was tried after replacing the equine serum with camel serum. Both media led to the same results and the second method was preferred as it is easier to use and is less expensive. Hence, using the skin snip technique and Tyrode's solution containing camel serum and antibiotics in the present survey on live Arabian camels in the Central Region of Saudi Arabia (Riyadh and Qasim Provinces) has resulted in an overall prevalence of 59.1 % in live camels of all ages. A similar prevalence was observed in camels slaughtered for human consumption at Abha abattoir, Asir Province by Nasher (1986). This was higher than the mere 34.2% reported by Cheema *et al.* (1984) during *post-mortem* examinations in abattoirs in other localities in the Kingdom. However, similar to the observations of Atta El Mannan *et al.* (1984), Hussein and El Sammani (1985) and Ferenc *et al.* (1986), the skin snip technique used for surveying live animals for onchocerciasis usually leads to a lower prevalence rate than it is. This is because the technique fails to detect recently acquired infections with immature worms in young camels, and also fails to detect many of the infections in old camels that harbour only dead and calcified worms. Hence, the skin snip technique is only epidemiologically sound in detecting onchocerciasis in young adult animals. Camels of such age group (2 - 8-year old) represented the bulk of the animals sampled over the 8-year period of the study, 751 (68.6%) in Riyadh Province and 407 (69.6%) in Qasim Province. Of these, 551 in

Riyadh Province and 343 in Qasim Province had mff in their skin snips, with a prevalence rate of 73.4% and 84.3%, respectively (Table 1). These rates are, as a matter of fact, the true reflection of the spread of onchocerciasis in camels in either Province determined by the skin snip technique. Moreover, camels in this age group (2 - 8 - year old) are, not only the most prevalent, but also they have the highest skin mff densities (Tables 1 - 4). Hence, they are epidemiologically the most important, as they are most likely the ones that provide the vectors with the infective feeds needed to maintain the spread of the infection. Hence, for sound epidemiological surveys of onchocerciasis in live animals, exclusively young adults should be examined by the skin snip technique, as has already been pointed out (El Bihari and Hussein 1978, El Sammani and Hussein 1983, Atta El Mannan *et al.* 1984, Hussein and El Sammani 1985, Ferenc *et al.* 1986, and Hussein *et al.* 1988). This is because the incidence of infection in this age-group does not vary significantly from the actual rate of infection detected during *post-mortem* examination. This is well demonstrated in the present study, where 773 and 90, 2 - 8-year old camels were studied by the skin snip technique during *ante-mortem* examination and at the same time their carcasses were examined for worms during *post-mortem* examination at Riyadh and Buraydah abattoirs, respectively. The skin snip technique has detected 511 infected camels of the 773 sampled at Riyadh abattoir and 68 of the 90 sampled at Buraydah abattoir. While the *post-mortem* examination has added only 26 (3.4%) infected camels to the former and only 3 (3.3%) to the latter, all of which were carrying dead and degenerated worms. Those additions were not statistically significant. Hence, from an epidemiological point of view, camels <1 -1-year old and 10- 20-year old should be removed from the present sample on the basis of their inability to contribute to the dynamics of the spread of the disease as they do not provide the vectors with infective feeds (Kennedy 1975) due to the absence of mff from their skin. Therefore, the actual prevalence of onchocerciasis in Arabian camels in Riyadh and Qasim Provinces of Saudi Arabia is respectively 73.4% and 84.3% and in the Central Region as a whole, 77.2% (Table 1) which is the highest prevalence recorded. Arabian camels in Asir Province, if similarly sampled might match the present prevalence rate which is higher than the 59% reported during *post-mortem* examination of camels of all age-groups. This suggestion is based on the excellent conditions in Asir Province which, similar to those in the agricultural regions of Qasim and Riyadh Provinces, are favourable for the efficient reproduction of the vectors of this infection and to the spread of these vectors (Kennedy 1975).

The vector (s) of *O. fasciata* in Saudi Arabia is not yet determined. Cheema *et al.* (1984) suggested that midges of the genus *Culicoides* (Diptera: Ceratopogonidae) are the most likely vectors. They based their suggestion on the greater prevalence of midges in Saudi Arabia than the other possible vectors, the blackflies of the genus *Simulium* (Diptera: Simuliidae). Blackflies occur in very limited locations in southwestern Saudi Arabia and there is no evidence of them biting camels (Crosskey and Büttiker 1982). Nevertheless, Nasher (1986) has unwisely dismissed the role of midges of the genus *Culicoides* as vectors of *O. fasciata* in Saudi

Arabia merely on the basis of his imagined limitation of distribution of midges to certain localities north of Latitude 25° N and he wrongly quoted Lane (1983) as his source. Lane (1983) had reported midges from Hofuf in Al-Hassa Oasis which is well south of Latitude 25° N. Moreover, midges were found, not only widespread in Saudi Arabia where they have been incriminated as vectors of bluetongue (Abu Elzein *et al.* 1992), but also throughout the Arabian Peninsula (Boorman 1989). One of us (H.S. Hussein - unpublished data) has collected *Culicoides kingi* Austen, 1912 and *Culicoides oxystoma* Kieffer, 1910 from Hotut Beni Tamim, Riyadh Province (Fig. 1), from Wadi Dallagan, near Abha, Asir Province and from Gizan, Gazan Province in southwestern Saudi Arabia. The former midge, *C. kingi* was also observed biting infected camels in a farm in Al-Khubra, Qasim Province (H.S. Hussein - unpublished data). This Afrotropical midge is widely distributed in Saudi Arabia (Lane 1983, and Boorman 1989) and is observed to bite camels. It is also a proven vector of *O. gutturosa* (El Sinnary and Hussein 1980, and El Sinnary *et al.* 1986) and has also been incriminated as a vector of other *Onchocerca* species (El Sammani and Hussein 1983, and Atta El Mannan *et al.* 1984). Hence, it could well be the vector of *O. fasciata* in Saudi Arabia. However, Nasher (1986) has the opinion that the identity of the vectors of either camel or human onchocerciasis in Saudi Arabia (Chumbly 1980, and El-Rifaie and El-Rifaie 1984) should only be considered after thorough surveys of *Simulium* and *Culicoides* species in the Kingdom followed by the collection of these insects for use in controlled transmission experiments to prove their role as vectors for camel or human onchocerciasis.

Nevertheless, the present results might indicate that midges could be the vectors of *O. fasciata* in Saudi Arabia. This is because, in the present study, sedentary camels in farms where conditions are favourable for the efficient breeding of midges have the highest rates of onchocerciasis than camels examined anywhere else. Moreover, even camels from free-ranging herds in Al-Ras, Qasim Province and in Al-Zulfi and Shagra, Riyadh Province where conditions favour the breeding of midges, have higher rates of onchocerciasis than their counterparts in the dry areas of Afif and Al-Dawadmi, Riyadh Province.

Similar to the observations of Cheema *et al.* (1984) and of Nasher (1986), the predilection site of adult *O. fasciata* in Saudi Arabian camels seems to be the *ligamentum nuchae*. The infection seems to start there, as camels <1- 1-year old had young onchocercal nodules only in the *ligamentum nuchae* and such nodules contain only immature worms. With subsequent infections and when most of the *ligamentum nuchae* has been infested with nodules, the infection seems to spread to other locations, mainly subcutaneously in the regions of the flanks. Moreover, in young adult camels (2 - 8-year old), nodules in the *ligamentum nuchae* were old, more heavily fibrosed and contained dead or degenerated worms. While in these same animals, young

nodules containing live and reproducing worms occurred subcutaneously in the regions of the flanks. Moreover, similar to the observations of El Bihari and Hussein (1978), Beveridge *et al.* (1979), Ladds *et al.* (1979), Atta El Mannan *et al.* (1984), Hussein and El Sammani (1985) and of Ferenc *et al.* (1986), the prevalence of onchocerciasis in Arabian camels in the Central Region of Saudi Arabia increased with the age of the animal. This very important epidemiological entity was not determined in previous studies conducted in the Kingdom and so is the differential in the prevalence of infection in male and female camels (Cheema *et al.* 1984, and Nasher 1986). Both sexes were found equally infected with *O. fasciata* in the present study. While Atta El Mannan *et al.* (1984) have found more Sudanese bulls infected with *O. armillata* than cows and Ferenc *et al.* (1986) have also found more bulls infected with *O. gutturosa* and *Onchocerca linealis* Stiles, 1892 than cows in Georgia and Florida, USA. However, similar to the observations of Nasher (1986), *O. fasciata* infections in camels is not seasonal and over the 8-year period of the present study, the infection was almost uniform throughout the various seasons of the year. This might be explained on the basis of the very slow spread of this rather chronic infection. Acute infections are the only ones that tend to be of a seasonal nature.

The present results indicate that *O. fasciata* mff have true predilection to the skin of the ears, head and neck regions that did not vary in either light or generalized infections. Hence, this predilection is not a factor of the distribution of the nodules in the body of infected camels as suggested by Cheema *et al.* (1984), but it is rather a true one, irrespective of adult location in infected animals as has been observed in other *Onchocerca* species (Eichler 1973, El Bihari and Hussein 1976, 1978, and El Sammani and Hussein 1983).

All of the camels sampled in the present study were quite healthy and did not show any symptoms of disease. This is similar to the previous observations of Cheema *et al.* (1984) and of Nasher (1986), as well as in other animal *Onchocerca* infections (Eichler 1973, Mellor 1973b, El Bihari and Hussein 1978, Atta El Mannan *et al.* 1984, and Hussein and El Sammani 1985). Similar to the observations of Hussein and El Sammani (1985) on *Onchocerca railletii* Bain, Muller, Khamis, Guilhon and Schillhorn van Veen, 1976 infections in donkeys, no signs of blindness nor of periodic ophthalmia were observed in any of the camels sampled in the present study. Moreover, no mff were observed in the eyes of infected camels, though Hussein and El Sammani (1985) did find mff inside the eyes of donkeys infected with *O. railletii*. On the other hand, no lesions that could be attributed to *O. fasciata* mff were found in the skin of infected camels. The skin thickenings due to acanthosis and hyperkeratosis observed by Cheema *et al.* (1984) was not observed in the present study. Such conditions were not observed in any of the animal onchocercal infections (Lagrulet 1962, Mellor 1973b, El Bihari and Hussein 1976, 1978, Atta El Mannan *et al.* 1984, Hussein and El Sammani 1985, Hussein *et al.* 1988, Awad *et al.* 1990). However, the general host reaction of camels towards adult *O. fasciata* infection is similar to that reported by Cheema *et al.* (1984) which consists of non-suppurative worm granuloma

formation with a less degree of fibrosis and cellular infiltration as observed in *Onchocerca volvulus* (Leuckart, 1893) Railliet and Henry, 1910 infection in man (Buen 1971) and in *O. gibsoni* infection in cattle (Nitisuwirjo and Ladds 1980). Hence, in this respect camel onchocerciasis is somewhat similar to, but also far less severe than equine onchocerciasis. (Mellor 1973b, Ladds *et al.* 1979, Schmidt *et al.* 1982, and Hussein and El Sammani 1985). This less severe pathological reaction is, however, only observed in camel onchocerciasis and could well be a function of the camel host. Moreover, the "burnet-out" reaction or mineralization of the nodules was also observed in the present study in old camels, and as indicated by Cheema *et al.* (1984), this could mean that *O. fasciata* infection in camels could well be self-limiting.

#### *Acknowledgments*

We are grateful for the technical assistance rendered by Ahmed Fadlalla. Thanks are also due to our ex-student, Saleh A. Al-Ghouraishi for help in the collection of samples from Al-Khubra, Qasim Province.

**Table 1.** The prevalence of *Onchocerca fasciata* in live Arabian camels (*Camelus dromedarius*) determined by the skin snip technique in the Central Region of Saudi Arabia (Qasim and Riyadh Provinces)

Province	Age groups (years)	No. of animals examined	No. of animals infected	Prevalence of infection (%)
Qasim	<1 - 1	102	0	0
	2 - 4	195	159	81.0
	5 - 8	212	185	87.0
	10 - 20	76	73	48.7
	Totals	-	585	380
Corrected totals*	2 - 8	407	343	84.3
Riyadh	<1 - 1	182	0	0
	2 - 4	358	247	69.0
	5 - 8	393	304	77.4
	10 - 20	162	62	38.3
	Totals	-	1095	613
Corrected totals*	2 - 8	751	551	73.4
Totals of Central Region	-	1680	993	59.1
Corrected totals*	2 - 8	1158	894	77.2

\* Correction is made by the removal of Camels <1- 1-year old and 10-20-year old from the sample because several of the former and many of the latter are infected but do not have microfilariae in their skin snips.

**Table 2.** The prevalence of *Onchocerca fasciata* infection in live Arabian camels (*Camelus dromedarius*) in Qasim Province determined by the skin snip technique.

Locality	Age group (years)	No. of animals examined	No. of animals infected	prevalence of infection (percent)	Mean mff g <sup>-1</sup> skin
Al-Bikiria	<1 - 1	15	0	0	0
	2 - 4	31	26	83.9	8680
	5 - 8	34	29	86.3	12508
	10 - 20	12	4	33.3	98
Totals	-	92	59	64.1	-
Al-Ras	<1 - 1	18	0	0	0
	2 - 4	41	28	68.3	4712
	5 - 8	45	36	80.0	4822
	10 - 20	14	6	42.8	68
Totals	-	118	70	59.3	-
Buraydah	<1 - 1	30	0	0	0
	2 - 4	50	43	86.0	11625
	5 - 8	52	46	88.5	14302
	10 - 20	22	14	63.6	1117
Totals	-	154	103	66.9	-
Onyza	<1 - 1	17	0	0	0
	2 - 4	36	28	77.8	8916
	5 - 8	38	33	86.8	12752
	10 - 20	15	5	33.3	1112
Totals	-	106	66	62.3	-
Riydah- Al-Khubra & Al-Khubra	<1 - 1	22	0	0	0
	2 - 4	37	33	89.2	10546
	5 - 8	43	41	95.3	15814
	10 - 20	13	8	61.5	1228
Totals	-	115	82	71.3	-
Totals of Qasim Province	-	585	380	65	-
Corrected totals	2 - 8	407	343	84.3	-

**Table 3.** The prevalence of *Onchocerca fasciata* infection in live Arabian camels (*Camelus dromedarius*) in Riyadh Province determined by the skin snip technique

Locality	Age group (years)	No. of animals examined	No. of animals infected	Prevalence of infection (percent)	Mean mff g <sup>-1</sup> skin
Afif	<1 - 1	16	0	0	0
	2 - 4	38	14	36.8	872
	5 - 8	39	21	53.9	1048
	10 - 20	20	3	15.0	48
Totals	-	131	38	33.6	-
Al-Dawadmi	<1 - 1	18	0	0	0
	2 - 4	40	18	45.0	986
	5 - 8	45	26	57.8	2118
	10 - 20	19	3	15.9	68
Totals	-	122	47	38.5	-
Al-Kharj	<1 - 1	18	0	0	0
	2 - 4	36	31	86.1	11628
	5 - 8	39	35	89.7	18814
	10 - 20	19	12	63.2	1258
Totals	-	112	78	69.6	-
Al-Majmah	<1 - 1	22	0	0	0
	2 - 4	34	28	82.4	8958
	5 - 8	40	38	95.0	14636
	10 - 20	14	6	42.9	2138
Totals	-	110	72	65.5	-
Al-Zulfi	<1 - 1	20	0	0	0
	2 - 4	38	26	68.4	8244
	5 - 8	43	34	79.1	8244
	10 - 20	17	5	29.4	988
Totals	-	118	65	55.1	-



Table 3. *Continued*

Locality	Age group (years)	No. of animals examined	No. of animals infected	Prevalence of infection (percent)	Mean mff g <sup>-1</sup> skin
Hotut Beni Tamim	<1 - 1	18	0	0	0
	2 - 4	42	35	83.3	10818
	5 - 8	48	40	83.3	14658
	10 - 20	18	10	55.6	1138
Totals	-	126	85	67.5	-
Layla	<1 - 1	22	0	0	0
	2 - 4	47	40	85.1	10518
	5 - 8	46	42	91.3	16518
	10 - 20	16	9	56.3	3124
Totals	-	131	91	69.5	-
Riydah	<1 - 1	30	0	0	0
	2 - 4	43	34	79.1	12678
	5 - 8	46	40	87.0	14412
	10 - 20	22	8	36.4	2018
Totals	-	141	82	58.2	-
Shagra	<1 - 1	18	0	0	0
	2 - 4	40	21	52.5	6538
	5 - 8	47	28	59.6	8416
	10 - 20	17	6	35.3	1116
Totals	-	122	55	45.1	-
Totals of Riyadh Province	-	1095	613	56.0	-
Corrected totals	2 - 8	751	551	73.4	-

**Table 4.** The prevalence of *Onchocerca fasciata* infection in Arabian camels (*Camelus dromedarius*) slaughtered for human consumption at Riyadh Central Abattoir and at Buraydah Abattoir

Locality	Age groups (years)	Ante-mortem skin snip examination				Post-mortem examination			
		No. of animals examined	No. of animals infected	Prevalence of infection (%)	mff g <sup>-1</sup> skin	No. of animals examined	No. of animals infected	Prevalence of infection (%)	% animals with worms but no mff in skin snips
Riyadh Central Abattoir	<1 - 1	42	0	0	0	42	3	7.1	100
	2 - 4	464	286	61.6	6414	464	301	64.9	3.2
	5 - 8	309	225	72.8	9230	309	236	76.4	3.5
	10 - 20	25	9	36.0	198	25	21	84.0	48.0
Totals	-	840	520	61.9	-	840	561	66.8	4.9
Buraydah Abattoir	<1 - 1	16	0	0	0	16	4	25.0	100
	2 - 4	54	40	74.1	10648	54	41	75.9	1.9
	5 - 8	36	28	77.8	14322	36	30	83.3	5.6
	10 - 20	12	3	25.0	218	12	9	75.5	50.0
Totals	-	118	71	60.2	-	118	84	71.2	11.0
Totals	-	958	591	61.7	-	958	645	67.3	5.6

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(Received 10/04/1993;  
in revised form 19/10/1993)

## داء كلابية الذيل (Onchocerciasis) في الإبل العربية في المنطقة الوسطى (منطقتي الرياض والقصيم) من المملكة العربية السعودية

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لقد أجريت هذه الدراسة في المنطقة الوسطى (منطقتي الرياض والقصيم) من المملكة العربية السعودية لمدة ثمانية أعوام (١٩٨٢ - ١٩٩٠م) حيث تم أخذ عينات من جلد الإبل الحية بواسطة آلة صممت خصيصاً لقطع قطع مستديرة من الجلد ذات قطر بواقع ١٥ مليمتراً تقريباً، وذلك بعد تحديد الموقع بمخدر البروكين الموضعي. وبهذه الطريقة وعلى مدى الثمانية أعوام، تم جمع عينات من ٦٨٠، ١ من الإبل من الجنسين وبأعمار مختلفة، ولقد كان الجمع يتم من جلد الخدين أو العنق وهي أماكن تجمع أجنة ديدان الفلاريا كلابية الذيل في الإبل. هذا ولقد كانت تُجمَع تلك العينات وتُوضَع مباشرة داخل حافظات ثلج محتوية على ثلج مهروس حيث تُرْسَلُ إلى المختبر. وفي المختبر يتم غسل تلك العينات جيداً بالماء والصابون، ثم تجفف بقطعة نظيفة من القماش القطني، وبعد ذلك يُحَلَقُ منها الشعر بواسطة شفرات حادة ثم تُقَطَّعُ إلى قطع صغيرة توضع داخل قوارير زجاجية صغيرة ذات أغشية معدنية (قوارير بيجو)

\* من تعنون له طلبات المستلآت.

تحتوي على ٨٠٪ من محلول تايرود و ٢٠٪ من مصّل الإبل مع مضادات حيوية لمدة ساعتين على الأقل، ثم تُفحصُ بعد ذلك عينات من المحلول بحثاً عن أجنة ديدان الفلاريا كلابية الذيل التي خرجت من تلك القطع حسب ما أشار به البحاري وحسين في الأعوام (١٩٧٥) و(١٩٧٦) و(١٩٧٨).

هذا ولقد دُعِمَت الدراسة أيضاً بأخذ عينات من جلد الإبل الحية عند الفحص قبل الذبح في مسلخي الرياض وبريدة لفحصها بالطريقة السابق ذكرها، ثم متابعة نفس الإبل بعد الذبح وفحصها بحثاً عن ديدان الفلاريا كلابية الذيل البالغة. هذا ولقد جُمِعَت قطع أكبر حجماً من جلود تلك الإبل وكمية من الدرنات التي تحدثها تلك الديدان وُحِلَّت للدراسة في المختبر.

لقد أوضحت الدراسة أن ٩٩٣ من الإبل الحية التي تم فحصها مصابة بداء كلابية الذيل ونسبة الإصابة ١, ٥٩٪، ولكن حينها عُدَّت النتيجة باستبعاد الإبل صغيرة السن (أقل من عام إلى عام من العمر)، وذلك وإن كان بعضها مصاباً إلا أنه لا توجد أجنة الديدان في جلودها نسبة لأن الديدان الموجودة في تلك الإبل لم تبلغ مرحلة التكاثر وإنتاج الأجنة بعد، وكذلك باستبعاد الإبل كبيرة السن (عمر ١٠ إلى ٢٠ عاماً) وذلك لأن كثير من المصاب منها لا يحمل أجنة الديدان في الجلد نسبة لأن الديدان الموجودة فيها ميتة ومتحللة داخل درنات متحجرة، وعليه فإن ٨٩٤ من ١١٥٨ من الإبل عمر ٢ - ٨ أعوام وجدت مصابة وبذلك تصبح النسبة الفعلية بداء كلابية الذيل هي ٢, ٧٧٪. هذا ولقد برهنت الدراسة أن النوع من الفلاريا كلابية الذيل الذي يصيب الإبل في مناطق الدراسة هو نوع *Onchocerca fasciata* والذي بُرِهِنَ من قبل بأنه النوع الوحيد الذي يصيب الإبل في المملكة العربية السعودية (انظر شيما وآخرون عام ١٩٨٤ وناشر عام ١٩٨٦).

وقد كانت الإبل في منطقة القصيم أكثر إصابة (٦٥٪ قبل التعديل، ٨٤, ٣٪ بعد التعديل) من الإبل في منطقة الرياض (٥٦٪ قبل التعديل، ٧٣, ٤٪ بعد التعديل)، كما وإن الإبل التي تم فحصها في المزارع المختلفة

كانت أكثر إصابة وفي جلودها أكثر كثافة من أجنة الديدان مقارنة بإبل الرحل الطليقة، وقد كانت أعلى نسب الإصابة في المناطق الزراعية في القصيم والرياض وأدناها في إبل الرحل الطليقة في منطقتي الدوادمي وعفيف غرب الرياض وهي أكثر مناطق الدراسة جفافاً، وقد فسّر ذلك بأن المناطق الزراعية هي أفضل المناطق لتكاثر الحشرات الناقلة لتلك الديدان والتي ربما تكون من حشرات الهوام جنس *Culicoides* من رتبة ثنائية الأجنحة. لم يوجد أي تباين في نسبة الإصابة بين ذكور وإناث الإبل ولكن تتفاوت تلك النسبة حسب عمر الحيوان حيث كانت أكثر الاصابات في الإبل عمر 5 - 8 أعوام، هذا وتبدأ الاصابات في الإبل من عمر مبكر وترتفع مع عمر الحيوان بحيث أن الإبل كبيرة السن توجد بها اصابات عديدة ولكن بديدان ميتة داخل درنات متحجرة. هذا ويبدو أن لديدان الفلاريا كلابية الذيل نوع *O. fasciata* إنجذاب نحو أوتار عنق الإبل حيث تبدأ الاصابات هناك أولاً وبعد إمتلاء تلك الأوتار بدرنات الديدان تنتشر الاصابات في بقية أنحاء جسم الحيوان، خاصة تحت الجلد في جانبي مؤخرة البطن.

الإبل المصابة بداء كلابية الذيل لا تبدو عليها أي أعراض مرضية، فهي تبدو بصحة جيدة مثلها مثل الإبل السليمة، هذا ولم نلاحظ في هذه الدراسة أي آثار مرضية ناشئة عن وجود أجنة تلك الديدان داخل جلود الإبل المصابة كما لاحظ ذلك شيما وآخرون (1984)، أما الديدان البالغة فتتسبب في نموء درنات تحيط بها، ولكن درجة الالتهاب ونموء الأنسجة الليلية كانت أقل بكثير في الإبل عن الاصابات بديدان الفلاريا كلابية الذيل فيما عداها من الحيوانات، كما وأن التحجر الواضح في درنات الإصابة في الإبل قد يشير إلى أن تلك الاصابات يمكن أن تنتهي من جراء نفسها، هذا ويطلق الجزارون المحليون في المسالخ على تلك الدرنات اسم الحجارة نسبة لترسب الأملاح الجيرية فيها مما يجعلها تبدو كالحجارة.