



Human myiasis in New Zealand: imported and indigenously-acquired cases; the species of concern and clinical aspects

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Abstract

Reports of myiasis in humans in New Zealand are somewhat rare, and little attention has been paid to this issue in the local medical literature. A number of Diptera (fly) families present in New Zealand have been associated with cases of human myiasis: Calliphoridae (7 species), Fanniidae (2 species), Muscidae (3 species), Oestridae (4 species), Phoridae (3 species), Psychodidae (1 species), Sarcophagidae (2 species), Stratiomyidae (1 species) and Syrphidae (1 species). Despite these numbers, there have only been 6 published records and we obtained further 16 unpublished reports of myiasis acquired in New Zealand. Records of imported myiasis in humans are also rare, with only 2 published and 6 unpublished cases obtained. As many medical practitioners are unaware of myiasis or encounter it rarely, we provide a brief discussion of the clinical features and treatment.

Myiasis is defined as “the infestation of live human and vertebrate animals with dipterous larvae, which, at least for a certain period, feed on the host’s dead or living tissue, liquid body-substances, or ingested food”.¹ From a parasitological perspective myiasis may be classified as obligatory, facultative or accidental.^{1,2}

Obligatory parasites—dependent on the host for a part of their life cycle.³ The larvae are deposited either directly on the skin or mucous membranes (e.g. *Oestrus* spp. and *Rhinoestrus* spp.), penetrate normal skin (e.g. *Gasterophilus* spp. and *Hypoderma* spp.), or become superimposed on pre-existing wounds (e.g. *Chrysomya* spp.).

Facultative parasites—normally free-living, with larvae developing in decaying organic matter,³ but which may occasionally contaminate living tissue, such as pre-existing wounds, ulcers and cavities (e.g. the genera *Musca* and *Calliphora*).

Accidental myiasis or pseudomyiasis—it occurs when the larvae of a normally free-living species are swallowed with contaminated food, passing through the alimentary canal where they may cause pathological reactions.¹

The literature on human myiasis in New Zealand is scarce, but recently two cases have been discussed in this journal, both of which were acquired overseas.^{4,5} In this review, we provide a comprehensive account of human myiasis in New Zealand by: i) examining the Diptera species present in New Zealand that have been associated with human myiasis; ii) reviewing the published and unpublished records of human myiasis in New Zealand, which were either indigenously-acquired or imported; iii) briefly outlining the diagnostic and clinical features of human myiasis and its treatment, as few medical practitioners in New Zealand are acquainted with such a condition.

Clinical features of human myiasis

Myiasis in humans may lead to a number of clinical features. Cutaneous myiasis is characterised by infestation of the skin and subcutaneous tissue, and is mostly caused by the larvae of obligatory parasites, although a number of facultative parasites may be associated with wound myiasis. Cutaneous myiasis can be sub-divided into furuncular, creeping, wound and subcutaneous:

- Furuncular myiasis—boil-like lesions develop either as a consequence of larvae penetrating the skin directly (e.g. *Dermatobia* spp.), or by migrating from other parts of the body, most often the gastrointestinal tract. The lesions can be painful or tender, with patients often aware of a sensation of movement.
- Creeping myiasis—larva migrans or creeping eruption is commonly caused by the larvae of certain parasitic nematodes (*Ancylostoma* spp. and *Uncinaria* spp.), but cases of larva migrans from a number of Diptera species have been recorded, such as *Hypoderma* spp. and *Gasterophilus* spp.⁶ Lesions characteristically develop where the skin comes into contact with the ground, namely feet, buttocks and trunk. The larvae appear to penetrate through hair follicles and sweat gland orifices, and then ‘creep’ through the subcutaneous layer, forming a pruritic erythematous line.
- Wound myiasis—this tends to occur accidentally in neglected wounds, where larvae are deposited in suppurating wounds or on decomposing flesh. Species within the genera *Cochliomyia* and *Chrysomya* are the more common causative agents. The diagnosis is obvious when larvae are visible on the surface of the wound but more difficult when they have burrowed beneath the surface. It is worth noting that wound myiasis may be intentionally employed as a medical procedure (maggot debridement therapy - MDT), in which fly larvae reared artificially in sterile conditions are used to remove necrotic tissue.⁷ This treatment appears to have originated from observations of the beneficial effects of maggot infestations in the wounds of injured soldiers.^{7,8} The most widely used species for MDT is *Lucilia* (= *Phaenicia*) *sericata* (Figure 1) due to its preference for feeding on necrotic over healthy tissues.⁷
- Subcutaneous myiasis—in this type of myiasis the larvae (e.g. *Hypoderma bovis* and *H. lineatum*) penetrate the subcutaneous tissue where they may remain for long periods, causing reddish, painful and oedematous masses that may develop into more classical furuncular myiasis.¹¹⁸ They can also induce a number of other dermatological eruptions including urticaria and erysipelas. More common sites are submaxillary, scapular and inguinal areas.¹¹⁸

Myiasis may also affect body cavities such as the ears, eyes, nose, and genitals, as well as the gastrointestinal tract:

- Ocular myiasis (ophthalmomyiasis)—may be external involving the eyelid or conjunctiva, or it can involve deeper structures of the eye itself. It is most commonly caused by *Oestrus ovis*, but it may be associated with other genera such as *Hypoderma* spp. Patients present with conjunctivitis, tear formation and the sensation of a foreign body in the eye. Vision may be impaired or lost,

and more serious pathologies including death may result in the most severe cases.

- Nasal myiasis—also most commonly caused by *Oestrus ovis*. Symptoms include a burning sensation of the nasal mucosa, often accompanied by epistaxis. It may be complicated by sinusitis, pharyngitis and rarely, meningitis.
- Aural myiasis—it occurs mainly as a complication of chronic ear infections. Perforation of the tympanic membrane can lead to mastoiditis and rarely, meningitis. Symptoms include hearing loss, tinnitus, pain and haemorrhage.
- Urogenital myiasis—has been reported to be caused by a number of genera. Symptoms may include discharge, abdominal pain and secondary infections. Urinary tract myiasis is usually caused by migration of larvae from bladder to the urethra, with symptoms as those of cystitis and urethritis.
- Gastrointestinal myiasis—it is primarily pseudomyiasis, and is associated with the ingestion of larvae, leading to signs and symptoms similar to those associated with intestinal parasites.

Figure 1. *Lucilia sericata*. Although an agent of human myiasis, this species is medically employed in maggot debridement therapy (adult photo courtesy of John Carr; larvae photo believed to be in the public domain)



Myiasis-causing flies established in New Zealand

There are no native fly species in New Zealand that are known to have caused myiasis in humans. Although numerous introduced species of Diptera present in New Zealand cause myiasis, most are not commonly associated with human cases. Nevertheless, a number of these have been recorded to cause human myiasis overseas (Table 1) and, in some rare instances, in New Zealand as well (Table 2).

Most of the species listed in Table 1 are not obligatory but rather facultative parasites. One such species is the common house fly *Musca domestica* (Figure 2), which is associated in particular with wound myiasis (Table 1). Although this species is

extremely widespread and abundant throughout the world, human myiasis caused by *M. domestica* appear to be relatively rare.⁹

A number of the species listed in Table 1 are obligate parasites of other mammals. For example, 15 years ago it was estimated that at least NZ\$30–40 million in annual losses were accrued by sheep farmers in New Zealand¹¹ due to myiasis associated with the blow flies (Calliphoridae) *Lucilia* (= *Phaenicia*) *cuprina*, *Lucilia* (= *Phaenicia*) *sericata*, *Calliphora stygia* and *Chrysomya rufifacies*.¹⁰⁻¹² These species are also occasionally found on other livestock such as goats and cattle,¹¹ but may cause myiasis in humans (Table 1).

Lucilia sericata in particular, seems to be associated with human wound myiasis in some countries,¹³ and less commonly in other forms of myiasis. Other species occasionally associated with ovine myiasis such as *Calliphora hilli* and *C. vicina* are also implicated in human myiasis (Table 1). In New Zealand, one case of aural myiasis caused by *Lucilia sericata* was recorded in the Waikato region (Table 3).

Recently two new introduced species of facultative parasites *Megaselia scalaris* and *M. spiracularis* (Phoridae) have been recorded in New Zealand.¹⁴ Larvae of *M. scalaris* have been associated with a number of cases of human myiasis, but human parasitism by *M. spiracularis* appears to be extremely rare (Table 1). Two other species of arguably lesser economic importance in New Zealand are *Oestrus ovis* and *Gasterophilus intestinalis* (Table 1). The only other member of the Oestridae in New Zealand, *Gasterophilus nasalis* is reported to be incapable of penetrating human skin,¹ but has been associated with gastro-intestinal myiasis (Table 1).

Figure 2. *Musca domestica*, the common house fly (adult photo courtesy of Joseph Berger; larvae photo courtesy of Clemson University, USDA Cooperative Extension Slide Series).



Table 1. Diptera species present in New Zealand and records of human myiasis caused by them overseas. The list of Diptera was primarily based on available resources^{14,63,64} and on information from known authorities on this group

Family	Species	Type of myiasis	References	
Calliphoridae	<i>Calliphora hilli</i> †	ophthalmic	65	
		<i>Calliphora vicina</i>	aural	6
			gastro-intestinal	6, 12, 66, 67
			nasal	68
			ophthalmic	17
			oral †	69
			urogenital	1
			wound	6, 67, 70
		<i>Chrysomya megacephala</i>	nasal/oral	6
			nasal	71
			wound	1, 6, 72
		<i>Chrysomya rufifacies</i>	wound	73
		<i>Lucilia cuprina</i>	gastro-intestinal	74
			nasal	75
			wound	1, 6, 13, 72
		<i>Lucilia sericata</i>	aural	6
			aural/nasal	1, 65, 76
			nosocomial	77, 78
			oral (possibly wound)	79
		wound	1, 6, 80	
	<i>?Pollenia rudis</i>	gastro-intestinal	6	
Fanniidae	<i>Fannia canicularis</i>	aural	6	
		gastro-intestinal	1, 66, 81	
		urogenital	1, 6, 82	
	<i>Fannia scalaris</i>	aural	6	
		gastro-intestinal	1, 66	
		rectal	83	
	urogenital	1, 6		
Muscidae	<i>Musca domestica</i>	aural	6	
		gastro-intestinal	1, 6, 66, 84	
		nosocomial	77	
		oral	9	
		urogenital	6, 85, 86	
		wound	1, 6, 13, 75, 87	
	<i>Muscina stabulans</i>	gastro-intestinal	6, 12, 66, 88, 89	
		rectal	90	
	<i>Stomoxys calcitrans</i>	gastro-intestinal	6, 91	
		wound	6	
Oestridae	<i>Gasterophilus intestinalis</i>	migratory	6, 8	
		gastro-intestinal	17	
		ophthalmic	1, 6	
		oral	92	
	<i>Gasterophilus nasalis</i>	gastro-intestinal	17	
	<i>Hydrotaea rostrata</i>	?	17	
	<i>Oestrus ovis</i>	nasal	12	
	ophthalmic	13, 24-28		
	pharyngeal	93		
Phoridae	<i>Megaselia scalaris</i>	gastro-intestinal	6, 94	
		nosocomial	78	
		ophthalmic	6	
		urogenital	95	

Family	Species	Type of myiasis	References
Phoridae (cont.)	<i>Megaselia scalaris</i> (cont.)	wound	1, 6
		<i>Megaselia spiracularis</i>	gastro-intestinal pulmonary
	<i>Piophilina casei</i>	gastro-intestinal	1, 6, 12, 66, 97
		nasal/oral urogenital	6 98
Psychodidae	<i>Psychoda alternata</i>	gastro-intestinal ophthalmic	6 99
Sarcophagidae	<i>Sarcophaga crassipalpis</i>	cutaneous	13
		ophthalmic	100
		wound	6, 101
	<i>Sarcophaga peregrina</i>	?	1, 102
Stratiomyidae	<i>Hermetia illucens</i>	wound	6
		cutaneous	103
Syrphidae	<i>Eristalis tenax</i>	gastro-intestinal	12, 104, 105
		gastro-intestinal rectal	1, 12, 66, 72, 106 107
		urogenital	12, 108, 109

† Identification uncertain.

Locally-acquired cases of myiasis

Despite the presence of the species listed in Table 1, cases of human myiasis acquired within New Zealand appear to be relatively rare (Tables 2 & 3). Seven cases were caused by the sheep botfly *Oestrus ovis*, and involved mainly ophthalmomyiasis externa (Tables 2 & 3).¹⁵⁻¹⁸ *Oestrus ovis* is widespread in New Zealand sheep flocks,¹⁹ causing excessive mucus production and obstruction in the nasal passages, and occasionally pneumonia. There is some debate regarding the extent to which it leads to significant economic loss.¹⁹ More recently, it has been shown that light infestations may be well tolerated, but heavy infestations can cause losses in meat and wool.²⁰

Oestrus ovis (Figure 3) is an obligate parasite primarily of sheep and goats, but humans and other animals such as dogs may become accidental hosts.^{1,21} Unlike many fly species, *O. ovis* deposit live larvae (rather than eggs) that infest the host immediately.¹ In their normal life cycle, the gravid female flies swarm around the heads of hosts, depositing larvae into the nostrils (and sometimes the eyes),¹ and the larvae migrate into the nasal mucus membranes where they mature.²²

Interestingly *O. ovis* is capable of depositing larvae whilst still in flight, ejecting them onto the host.²² The stimuli for larviposition in *O. ovis* are not completely understood, but movement of a potential host is required, and perhaps light colouration, while the configuration of the human face has also been suggested as important.²³

The sheep botfly is regularly associated with human ophthalmic myiasis worldwide,^{13,22,24-28} but there are reports of nasal and pharyngeal myiasis as well (Table 1). Ophthalmic myiasis usually causes minor localised irritation, but it may lead to severe sequelae including disfigurement, blindness, and even death.^{28,29}

Table 2. Published records of imported and indigenously-acquired cases of human myiasis in New Zealand

Origin of infestation	Species	Type of myiasis	References
Imported	<i>Dermatobia hominis</i>	cutaneous	5, 110
New Zealand	<i>Gasterophilus intestinalis</i>	cutaneous	30
	<i>Oestrus ovis</i>	ophthalmic nasal	15, 16, 17, 18 15

Table 3. Unpublished accounts of imported and indigenously-acquired cases of human myiasis in New Zealand

Origin of infestation	Species	Comments
Imported	? <i>Dermatobia hominis</i>	<ul style="list-style-type: none"> • ca.1999. Female tourist arriving in New Zealand from Latin America. A single unidentified larva was removed from the patient's skin in the occipital region. In view of the country of origin of the infestation, the species involved is presumed to be <i>D. hominis</i> (Joan Ingram, pers. comm. 2009). • 2008. Cutaneous myiasis on tourist arriving from the Amazon region. Species presumed to be <i>D. hominis</i> (Kerry Read, pers. comm. 2009).
	<i>Dermatobia hominis</i>	<ul style="list-style-type: none"> • March 1999, Auckland Hospital. A 2nd-instar larva surgically removed from the right shoulder of a female tourist arriving in New Zealand from Bolivia (Trevor Crosby, pers. comm. 2010). • April 1999, Auckland Hospital. A 3rd-instar larva removed from the leg of a female tourist arriving in New Zealand from Bolivia (Trevor Crosby, pers. comm. 2010).
	Unidentified sp.	<ul style="list-style-type: none"> • 2009. Waitakere Hospital. No details available, except that the patient was a New Zealander who had recently returned from a trip to South America (Fiona Larsen, pers. comm. 2010).
New Zealand	<i>Eristalis tenax</i>	<ul style="list-style-type: none"> • Two cases of intestinal myiasis, the most recent of which was recorded in a patient from Blenheim in 2000. No further information is available (Graeme Paltridge, pers. comm. 2010).
	<i>Lucilia sericata</i>	<ul style="list-style-type: none"> • April 1999, Waikato Hospital. Numerous larvae were removed from the left mastoid cavity of an 81-year-old male (Dallas Bishop, pers. comm. 2009).
	<i>Oestrus ovis</i>	<ul style="list-style-type: none"> • January 1997, Hamilton. First instar larva removed from the eye of a human male (larva submitted to ACG Heath at the time by WG Elmsbury). • February 2005, Auckland Hospital. Three first instar larvae were removed from the eye (conjunctival sac) of a woman who lived in semi-rural Auckland (larvae provided to ACG Heath at the time by James Usher, LabPlus).
	Unidentified sp.	<ul style="list-style-type: none"> • Waikato Hospital. Three cases of wound myiasis on leg ulcers on elderly patients, as a result of poor care (pers. obs.). • Palmerston North. No date or details available, except that the patient had extensive myiasis on the leg (Scott Barker, pers. comm. 2010). • 1995. Napier. Myiasis on leg ulcers of a male indigent, as a result of poor wound care (Ian McQuillan, pers. comm. 2010). • 2002, wound myiasis on a mentally ill woman from Canterbury as a result of poor wound care (Graeme Paltridge, pers. comm. 2010).

Figure 3. *Oestrus ovis*, the sheep botfly (adult photo courtesy of Anthony Daley; larvae photo courtesy of the Universidad Autònoma de Barcelona)



Although the larvae of some flies may cause irreversible damage to orbital contents (e.g. *Cochliomyia hominivorax*),²⁸ *O. ovis* ophthalmic myiasis is said to be self-limiting in humans, as the larvae generally do not develop beyond first stage in the human eye.^{1,22} As a result, the course of *O. ovis* myiasis is almost invariably benign conjunctival myiasis (ophthalmomyiasis externa) in healthy human hosts.²⁸ Since *O. ovis* is widespread in New Zealand,¹⁹ and its clinical effects are relatively minor, it is likely that numerous cases of *O. ovis* ophthalmomyiasis externa go unreported.

One case of cutaneous myiasis in New Zealand due to *Gasterophilus intestinalis* (the horse botfly; Figure 4) has also been recorded.³⁰ Horses are the primary hosts for this botfly, in which the larvae migrate through the animals' alimentary canal to complete their life cycle.³⁰ This does not occur in humans, and infestation appears to be limited to cutaneous myiasis. As with *O. ovis*, *G. intestinalis* appears incapable of developing beyond the first larval stage in human hosts.^{17,30}

Figure 4. *Gasterophilus intestinalis*, the horse botfly (adult photo courtesy of Robert Nash; larva photo courtesy of Kalumet)



There have been at least two recorded cases of intestinal myiasis caused by *Eristalis tenax* (Figure 5; Table 2), but no specific details have remained for any of the cases (Graeme Paltridge, pers. comm. 2010). *Eristalis tenax* (Syrphidae; commonly known as hover fly or drone fly) is a cosmopolitan species. There are occasional records of myiasis associated with it, particularly of accidental intestinal myiasis (Table 1) resulting from the ingestion of contaminated food.¹⁰⁶ Clinical presentation is varied, and although it may be asymptomatic some patients may experience abdominal pain, nausea and vomiting.¹⁰⁶

Figure 5. *Eristalis tenax*, the drone-fly or hover fly. Note the bee-like appearance of the adult and the characteristic ‘rat-tailed’ larva (adult photo courtesy of Fir0002/Flagstaffotos; larva photo courtesy of Jarmo Holopainen)



Despite the lack of published records, myiasis associated with infected wounds does occur in New Zealand (Table 3). Although we do not know the frequency of such occurrences or the species involved, these seem to be primarily opportunistic myiasis associated with the elderly at home, as a result of poor wound care (pers. obs.; Graeme Paltridge, pers. comm. 2010).

Lastly, an article from Japan describes the case of a woman who apparently contracted cutaneous myiasis by the cattle warble fly, *Hypoderma bovis* (Oestridae), while travelling in New Zealand.³¹ This species has not established in the Southern Hemisphere,¹⁹ and it does not occur in New Zealand, although it has been introduced at least once on imported cattle from the UK (G. Adlam, pers. comm. 1977). Since *H. bovis* is established in Japan,³² the infestation most likely occurred in that country.

Imported cases of myiasis

Imported cases of human myiasis are a worldwide occurrence among travellers returning from the tropics.³³⁻³⁸ Although a few fly species may be involved, human cases appear to be caused primarily by *Dermatobia hominis* (Cuterebridae; Figure 6)^{33,35,37,39} and *Cordylobia anthropophaga* (Calliphoridae).³⁵⁻³⁸ Both species have a life cycle that alternates free-living and parasitic stages, causing primarily cutaneous myiasis.

Figure 6. *Dermatobia hominis*, the human botfly (adult photo courtesy of Lyle J Buss; larva photo courtesy of Medical Illustrations, Christchurch Hospital)



Although these are particularly common overseas, cases of myiasis in travellers returning to New Zealand are rarely described. We have been able to ascertain the occurrence of only seven cases of imported myiasis in New Zealand, just two of which have been published in the medical literature (Tables 2 & 3). *Dermatobia hominis* was the likely culprit in six cases (certainly in two); a case of wound myiasis due to *Lucilia cuprina* imported from Fiji has also been recorded (Tables 2 & 3).

Surprisingly, there seems to be no recorded cases of *Cordylobia anthropophaga* myiasis imported into New Zealand (the larvae in Edwardes⁴ was removed while overseas), but in view of its importance in cases worldwide we provide a more in depth discussion of this species and *D. hominis* as well.

Dermatobia hominis

The human botfly is widespread in tropical and subtropical Latin America, from the south of Mexico to the north of Argentina,^{40,41} and one report suggests that it is established in Saudi Arabia.⁴² The adult fly lays eggs on the body of anthropophilic insects which they catch, usually mosquitoes (Culicidae), but flies from six other Diptera families have also been implicated as vectors.⁴³ Eggs remain attached to the vector and emerge upon contact with the skin of the host, eventually penetrating the skin and disappearing into the subcutaneous tissue.⁴³ The range of hosts includes a large number of vertebrates such as humans, monkeys, most domestic animals, and birds.^{41,44} Although cases of *D. hominis* myiasis are primarily cutaneous, there are a number of records of ophthalmomyiasis.⁴⁵ In some cases, the larvae may burrow into deeper tissues causing severe symptoms: deaths from larvae burrowing through the fibrous portion of the fontanelle of neonates have been reported.^{44,46}

The larvae are parasitic from the 1st to 3rd instars,⁴⁰ taking 30 to 40 days for larval development to occur.⁴⁷ Eventually larvae will abandon the host, falling onto the soil where they pupate, developing into adults some 30 to 60 days later.⁴⁷ The incidence of *D. hominis* is directly related to suitable climatic conditions,^{40,48} preferring a high relative humidity and high mean temperatures (ca.20°C).⁴¹ Although *D. hominis* is present in subtropical South America, it seems unlikely that it would encounter

suitable climatic conditions for establishment even in the warmest regions of New Zealand.

Cordylobia anthropophaga

The tumbu fly is widespread in sub-Saharan Africa,³⁶ and it is a common cause of human myiasis^{36,49,50} *Cordylobia anthropophaga* females lay egg batches directly on dry shaded ground, but these are also laid on laundry.⁵⁰ As a result, cutaneous myiasis can occur from contact with infested clothing, leading to parasitism in normally unexposed areas of the body, such as the genitals.^{51,52}

Larvae hatch in 1–3 days but may survive for 9–15 days un nourished, until activated by the host's body heat or movement.^{2,50} They are able to attach themselves and immediately burrow into the skin of an unsuspecting host, remaining at the site of entry, where they grow for 8–15 days in a furuncle-like lesion.^{2,50,53} Once the growth period is over, the third stage larva leaves the furuncle, falling to the ground to pupate.^{50,53} Apart from humans, *C. anthropophaga* is known to affect dogs and rats,² but it is likely to also infest a range of other hosts.

Myiasis due to *C. anthropophaga* are likely to be relatively benign as the larvae do not migrate into deeper tissues.^{2,53} Further, it seems that *C. anthropophaga* larvae secrete an antibacterial fluid, which may prevent secondary infection.⁵⁴

Prevention relies on ironing clothes prior to use, or drying them in full sunlight or under a mosquito net.^{36,55} Insect repellents are considered ineffective in the prevention of this myiasis.³⁶

Although *C. anthropophaga* is a common cause of myiasis in travellers returning from endemic areas,^{35,36} the evidence that it has become established outside its African range and Saudi Arabia^{2,36} is poor and based solely on isolated case reports. These include cases in England,⁵⁶ Netherlands,⁵⁷ and Spain.³⁶ A further report from Britain claims that the infestation was acquired in Portugal.⁵⁸ However, although the patient herself had not visited any known endemic areas prior to her return to the UK, one cannot disregard the possibility that she had been in contact with contaminated clothing brought from Africa, as happened in cases acquired in England⁵⁶ and Australia.¹¹⁹

One report from Japan describes successful emergence of a *C. anthropophaga* adult from a pupa at room temperature,⁵⁹ but this is unlikely to have occurred outdoors, and even more unlikely to have successfully led to an established population. In view of its tropical distribution and the species' lack of establishment in countries with warmer climates and greater frequency of imported cases, the risk of *C. anthropophaga* becoming established in New Zealand is considered to be very low.

Diagnosis and treatment in New Zealand

As is the case with other rare conditions, diagnosis of myiasis may be easily missed. However, since Diptera species able to cause myiasis in humans are present in New Zealand and the rate of international travel continues to increase, it is important that primary care physicians and nurses are aware of the clinical features of myiasis.

Patients often describe the sensation of movement under the skin in association with a lesion resembling a boil or furuncle.⁶⁰ In the case of exotic species such as *D. hominis* and *C. anthropophaga*, such symptoms would be associated with recent travel history to the tropics, providing the attending medical practitioner with clues to reach an appropriate diagnosis. However, whilst the absence of recent travel to the tropics minimizes the likelihood of myiasis, it does not entirely exclude it, in view of the fly species present in New Zealand.

Numerous techniques have been employed to remove the larvae.⁶⁰ In the case of furuncular lesions, occlusion of the skin pore for up to several hours to block the larva's breathing orifice is a widely used method. This can be achieved with a variety of substances such as petrolatum, paraffin, beeswax, pork fat or chewing gum.^{60,61} These force the larva to protrude its posterior spiracle in search of air, consequently facilitating its removal. This is a useful technique as some botflies have a tapered shape with rows of spines and hooks which prevent simple extrusion through the central punctum (Figures 4 & 5).

When the larva surfaces for air, it can be manually extracted with the aid of forceps, with care not to puncture the larva. Alternatively, ethyl chloride sprays, liquid nitrogen, 15% chloroform in oil or 1% ivermectin cream have been used alone or in combination. Additionally, lidocaine can be injected into the base of the tissue cavity which the larva inhabits, thereby forcing the larva to the surface through hydrostatic pressure.¹¹²

Pressure extraction by the application of slow, firm pressure to the sides of the lesion (similarly to squeezing an acne spot) is commonly used. A study in Ethiopia found that 87% of rural residents used this method to remove *C. anthropophaga* larvae.⁶² However, this can result in secondary infections, abscesses, severe inflammatory reactions and even fatal outcomes due to incomplete removal of the larvae.^{54,62} Therefore, it is important to extract the larvae in its entirety.

If the larva cannot be easily extracted, it may be necessary to enlarge the opening with a small incision under local anaesthetic. Alternatively, the whole lesion (and larva) can be primarily excised under local anaesthetic. It is important that the wound is thoroughly cleaned after removal of the larva.

For wound and cavitory myiasis, the cavity or wound can be irrigated with 15% chloroform in oil or soaked with 1% ether.^{113,114} Larvae can then be removed with forceps using an aseptic technique. Ivermectin has also been used for some cases of myiasis, particularly involving the eye and mouth.¹¹⁵⁻¹¹⁷

Conclusions

It seems that the most important myiasis-causing species in New Zealand is the sheep nasal botfly *Oestrus ovis*. However, since such cases tend to be self-limiting, and the infestation is usually benign, it is likely that the majority of cases go unreported in the literature. As a result, the actual prevalence of myiasis in New Zealand is likely to be considerably greater than what is reported.

The increasing rate of international travel and the consequent greater number of travellers arriving from tropical regions is likely to lead to an increase in the number of cases being imported into New Zealand.

Fortunately, the main species involved are not likely to become established in New Zealand and are therefore unlikely to pose a biosecurity risk, although this risk assessment may change in the future under a climate change scenario. Nonetheless, it is important that medical practitioners are acquainted with the diagnosis and treatment of myiasis.

Also, in order to obtain an accurate estimate of myiasis incidence in the country, we encourage that such cases are appropriately recorded and/or published in the medical literature. For this purpose, assistance with larval identification can be obtained (ACG Heath; email: allen.heath@agresearch.co.nz).

Ideally, specimens should be preserved in a solution of 70% ethanol and 30% distilled water, but if necessary they may be also preserved in methylated spirits or spirituous liquors, which are likely to be available in most homes in New Zealand.

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