Review

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Review

Ophthalmomyiasis Externa and Importance of Global Warming: A Case Report by *Lucilia sericata* and Review of the Medical Literature

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Abstract: Myiasis is a medical condition in humans caused by the larvae and worms of certain types of flies, specifically the Sarcophagidea species. If this parasitic infection occurs in the external part of the eye, it is known as external ophthalmomyiasis. This condition is more commonly found in the Mediterranean and the Near East and is rare in North America. Objective: This report and review aim to describe and compare the risk factors, clinical course, and parasitologic features of external ophthalmomyiasis. We also discuss the different preventive measures in a large case series reported from January 2000 to December 2022. *Methods*: We report the first case of external ophthalmomyiasis in Mexico caused by *Lucilia sericata* in an adolescent with no clinical risk factors. Additionally, we perform a literature review of reported cases of external ophthalmomyiasis to determine the clinical characteristics, therapeutic management, and information on the organisms that most commonly cause external ophthalmomyiasis. Results: A total of 312 cases of external ophthalmomyiasis were recorded, with 208 cases in males (66.7%) and 102 cases in females (32.7%). In two cases, the gender and species responsible for the ophthalmomyiasis were not reported (0.6%). The mean age of those affected was 32.1 ± 18.5 years, ranging from newborns to 91 years old. The male-to-female ratio was 2:1. The most common causative organism was *Oestrus ovis*, accounting for 72.1% of cases, followed by *Dermatobia hominis* at 5.4%, *Lucilia sericata* at 0.96%, and *Chrysomyia bezziana* at 0.96%. Before experiencing symptoms, 43.6% of cases reported having direct contact with flies or being hit in the eye, 33% reported no associated risk factors, 9.3% reported living with sheep and goats, and 7.7% reported a history of foreign objects entering the eye. The most common symptoms for those affected by *Oestrus ovis* were sudden onset, including a foreign body sensation and movement, redness, tearing, itching, swelling, irritation, photophobia, burning, and ocular secretion. In cases caused by *Dermatobia hominis*, symptoms included eyelid edema, pain, redness, itching, movement within the lesion, ocular irritation, and discharge. Regarding occupational or recreational activity, agriculture and livestock had the highest incidence, followed by trades and technical activities, being a student, and having traveled to an endemic region for work or recreation. Conclusion: Patients with red eyes may suffer from external ophthalmomyiasis, which requires a thorough examination to diagnose and treat it early. Moreover, as the temperature increases due to climate change, it is essential to consider how this will affect the spread of different pathogens. Specifically, the life cycle of *Oestrus ovis* is greatly influenced by temperature, which suggests that the incidence of ophthalmomyiasis will rise with warmer temperatures.

Keywords: external ophthalmomyiasis; *Lucilia sericata*; *Oestrus ovis*; *Dermatobia hominis*; conjunctival myiasis; external ocular myiasis; global warming; red eye; Mexico

1. Introduction

The term "myiasis" [1] was coined in 1837 by Frederik William Hope to describe a disease caused by fly larvae or eggs (maggots) that feed on the host tissue during a specific developmental stage. The condition does not result from adult flies. Myiasis can affect humans and animals, leading to various clinical presentations [2,3].

Myiasis is a type of infestation categorized as obligate, facultative, or accidental. Obligate myiasis is mainly caused by fly larvae (*Dermatobia, Cordylobia,* and *Oestrus*), which cannot obtain enough nutrients from their mother fly. In animals, blowfly larvae are the primary cause of myiasis and can also affect humans as a zoonosis. The most common type of myiasis among humans is caused by *Dermatobia hominis* [4], whose larvae are spread via mosquitoes by laying their eggs on mosquitos' wings. *Cordylobia anthropophaga* is spread through urine and feces. Facultative myiasis is caused by bluebottle flies (*Phormia, Lucilia,* and *Musca*), and some of their larvae (*Lucilia sericata*) release bacteriolytic enzymes that can be used to sterilize infected wounds [5].

Myiasis is becoming more common in environments with poor hygiene [2], primarily where human activity occurs. Although rare in humans, it is observed in tropical and subtropical areas with suboptimal housing conditions [6]. Poor hygiene, alcoholism, trauma, senility, mental or neurological diseases, immunosuppression, diabetes, malnutrition, and suppurative lesions [7] are all risk factors associated with human myiasis. The prevalence of myiasis depends on climatic and ecological factors as well as the fly population and susceptible animals [8]. Larvae can invade various body parts, including the mouth, nose, eyes, lungs, ears, sinuses, anus, brain, and vagina [6]. Ophthalmomyiasis, or ocular myiasis, is a form of myiasis that specifically affects the human eye. However, it represents less than 5% of all human myiasis cases [3]. Ophthalmomyiasis can range in severity from mild irritation to blindness or even death [9]. Depending on the location of the infestation, myiasis is classified as external, internal, or orbital. External myiasis occurs when larvae are present in the conjunctiva, sclera, eyelids, and tear ducts, including palpebral and conjunctival myiasis. Internal myiasis occurs when larvae penetrate the eye. Meanwhile, orbital myiasis is the least common type and occurs when larvae invade the orbit, potentially leading to the rapid destruction of the eyeball [2,3,9,10].

In 1900, Keyt reported the first case of ophthalmomyiasis [11]. The most common cause of ophthalmomyiasis externa Oestrus ovis ("sheep fly") larvae [12]. Dipterous flies known to cause ophthalmomyiasis externa include the sheep nose fly (*Oestrus ovis*) and the human horsefly (*Dermatobia hominis*), and are endemic to tropical countries, with other examples including rodent horseflies of the genus *Cuterebra* and horseflies of the genus *Gasterophilus*, the housefly (*Musca domestica*), and the bovine fly (*Hypoderma*). Of these, *Oestrus ovis,* which is an obligate parasite of sheep and goats, with humans occasionally becoming accidental hosts, has a cosmopolitan distribution and has been reported to be the most common causative agent of ophthalmomyiasis externa [12–14].

External ophthalmomyiasis is rare in Mexico, with only two cases reported so far [15,16]. We present the first case of external ophthalmomyiasis caused by *Lucilia sericata* in an adolescent with no known risk factors. Our comprehensive literature review provides valuable information on the various risk factors, clinical course, parasitological and environmental characteristics, and treatment options for this condition. In addition, we discuss preventive measures based on a case series reported between January 2000 and December 2022.

2. Case Report

On August 11, 2022, a 15-year-old adolescent with no medical history or risk factors arrived at the Hospital General de Pachuca emergency department complaining of ocular pain, a foreign body

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sensation, tearing, and redness in his right eye. He had been experiencing these symptoms for a day after lifting a piece of lumber and feeling something fall into his eye. Although his mother had removed six larvae, the patient's symptoms persisted. Upon examination, the ophthalmologist observed discharge, congestion, and conjunctival hyperemia. A mobile larva was discovered in the right conjunctival sac fundus. The patient was treated with ophthalmic antibiotics and corticosteroids but did not return for follow-up. Larvae collected were sent to the entomology laboratory of the Instituto de Diagnóstico y Referencia Epidemiológicos (Epidemiological Diagnostic and Reference Institute or InDRE) for taxonomic analysis. The specimens collected were of 1.0 mm in length and of a beige color. The larvae were initially stored for two days in formaldehyde and subsequently preserved in 70% ethyl alcohol permanently. The larvae were prepared for microscopic study. Photographs were taken of the slides using an Infinity 1 Lumenera® digital camera through Olympus microscopes (BX50 and SZX7) and then edited in Adobe Photoshop®. entomology laboratory at the InDRE used these slides (magnified to 4x and 10x) and a SZX7 stereoscope and an Olympus BX43 optical microscope to identify the species of the larvae using their morphological characteristics. A literature review was performed to inform the taxonomical differentiation of these specimens against other members of the Oestroidea superfamily, especially the *Calliphoridae*, Cuterebridae, and Oestridae families. The morphological identification revealed that the larvae obtained from the patient belonged to the *Calliphoridae* family, and all were in larval stage I of their life cycle, revealing it to be a *Lucilia sericata* (Diptera *Calliphoridae*) first-instar larva (Figure 1).

The occurrence of ophthalmomyiasis caused by *Lucilia sericata* and other species of the *Calliphoridae* family has only been observed in patients with existing wounds that emit a foul odor and are infected with bacteria. These wounds are typically located in or around the orbit and contain dead tissue [17,18], attracting the flies due to blood and bacterial volatiles [19]. Neglected, malodorous wounds in patients who cannot care for themselves [20] are prone to infestation by these flies. While *Lucilia sericata* is known to infest human skin wounds, other areas such as the eyes, nose, sinuses, throat, and urogenital tract [17] are less-common infestation sites. It is important to note that mechanical transmission of flies in a hospital environment is also possible [21].

An external eye infection caused by *Lucilia sericata* in a healthy Mexican patient with no previous risk factors is an infrequent occurrence. This case is the first ever reported in Mexico and the second worldwide. Despite its common nature, it is highly unusual for an adolescent patient to be infested with a conjunctival worm, given its life cycle and characteristics.

In the past 22 years, only three scientific articles have explored external ophthalmomyiasis caused by *Lucilia sericata*. While two cases were linked to risk factors such as prior eye injuries, life-threatening conditions, and cancerous skin growths [17,18], one involved a typically healthy 72-year-old farmer with no underlying health issues [22]. Conversely, our report is the second case of an infestation by the facultative parasite *Lucilia sericata* in a healthy teenager with no history of injury, surgery, or illness. Physicians must remain vigilant of facultative and obligate parasites, even in previously healthy individuals without risk factors.

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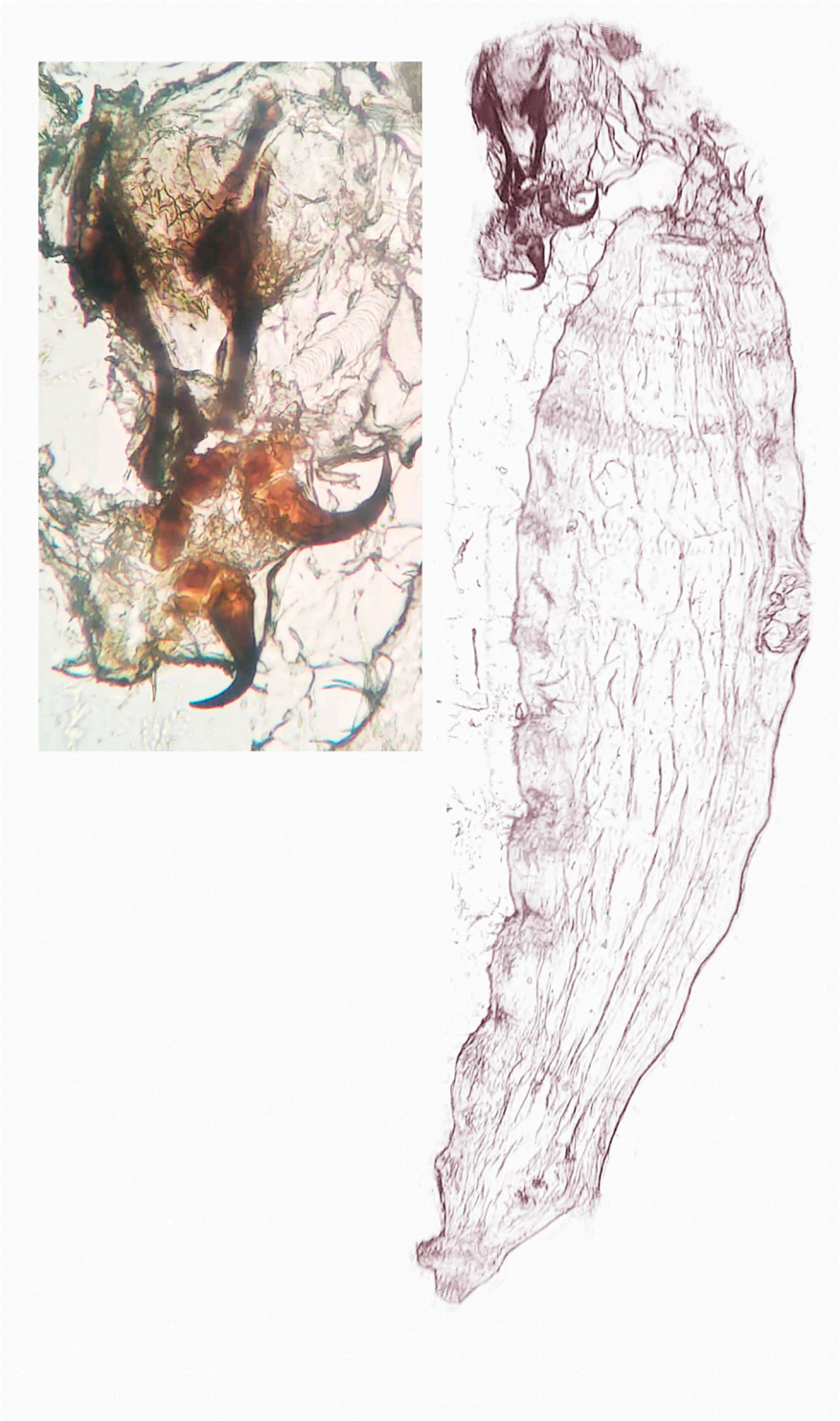

Figure 1. Larva first stage. A. lateral view. B. Details of mount parts.

3. Review of the scientific literature

We conducted a thorough search of electronic databases (Latin American and Caribbean Literature in Health Sciences, http://lilacs.bvsalud.org; Scientific Electronic Library Online, http://www.scielo.org; PubMed, http://www.ncbi.nlm.nih.gov/pubmed; EBSCOhost, http://www.ebscohost.com; and Google Scholar, http://scholar.google.com) and individual journals, including articles in English and other languages (German, Turkish, French, and Italian) published between January 1, 2000, and December 31, 2022, on external ophthalmomyiasis, external ocular

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myiasis, and conjunctival myiasis. Our research strategy was comprehensive, utilizing a combination of general terms ("ophthalmomyiasis", "external ophthalmomyiasis", "superficial ophthalmomyiasis", "human ophthalmomyiasis", "conjunctival myiasis", "ocular myiasis", "external ocular myiasis", "palpebral myiasis", "accidental myiasis", "oestrosis", "*Oestrus ovis*", "*Dermatobia hominis*", "*Cochliomyia hominivorax*", "*Chrysomyia bezziana*", "*Lucilia sericata*", "*Musca domestica*", "myiasis", "sheep fly", "sheep blowfly", "diptera larvae", "maggots", "Ivermectin", "sheep", "zoonosis", "acute presentation", "conjunctivitis/Differential diagnosis", "unilateral conjunctivitis", "acute unilateral conjunctivitis", "red eye", "keratouveitis", "keratitis", "ocular", "ocular infestation", "ocular foreign body", "red eye", and their combinations) and cross-referencing to identify relevant articles. We only selected articles that reported external ophthalmomyiasis and met the eligibility criteria.

4. Results

4.1. Epidemiological information

Myiasis is a condition usually seen in rural or low-income regions where people are in close proximity to farm animals. Nevertheless, there has been an increase in reported cases in urban areas without known risk factors [23]. The yearly occurrence rate in Africa and the Middle East is 10 cases per 10,000 population, but instances have also been recorded in Australia, North America, and Southern Europe [24].

After searching various databases, we found 117 articles that discussed 312 cases of external ophthalmomyiasis from 2000 to 2022. Among these cases, 208 were male, 102 were female, and 2 did not disclose their sex, resulting in a male-to-female ratio of 2:1. The average age of the patients was 32.1 years, with the youngest case being a few days old and the oldest being 91 years old. It is worth noting that this condition predominantly affects adults aged 20-59 and adolescents aged 10-19 [1].

India reported the highest incidence of cases from 2000 to 2022, accounting for 62 (19%), followed by Jordan with 50 (16.03%), Turkey with 45, Iran with 27, and Libya with 22. Notably, 17 countries reported one case each, with the patient in each case having traveled to endemic countries for tourism or work.

Oestrus ovis larvae were the culprit in 225 cases, representing 72.12% of all reported cases. In 56 instances, the cause remained unidentified. *Dermatobia hominis* was pinpointed in 17 cases, while *Lucilia sericata* and *Chrysomyia bezziana* were each discovered in 3 cases (Table 1). Agriculture and livestock were the most common activities associated with the reported cases, followed by trades/technical activities and recreational or work trips to endemic countries.

Table 1. Geographical distribution and agents responsible for external ophthalmomyiasis from 2000 to 2022.

Country	Number	Percentage	Causative agents
India	62	19.9	*Oestrus ovis, Musca domestica, Chrysomya bezziana*
Jordan	50	16.0	*Oestrus ovis*
Turkey	45	14.4	*Oestrus ovis, Chrysomya bezziana*
Iran	27	8.7	*Oestrus ovis, Lucilia sericata*
Libya	22	7.1	*Oestrus ovis*
Tunisia	12	3.8	*Oestrus ovis*
French Guiana	10	3.2	*Dermatobia hominis*
Italy	10	3.2	*Oestrus ovis*
Spain	10	3.2	*Oestrus ovis, Dermatobia hominis*
USA	8	2.6	*Dermatobia hominis, Oestrus ovis, Phaenicia lucilia*
Germany	6	1.9	*Oestrus ovis*
France	6	1.9	*Oestrus ovis*
Peru	5	1.6	*Oestrus ovis*
Israel	4	1.3	*Oestrus ovis, Sarcophaga argyrostoma*

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Brazil	4	1.3	*Dermatobia hominis, Cochliomyia macellaria*
Oman	2	0.6	*Oestrus ovis*
Republic of Croatia	2	0.6	*Oestrus ovis*
Saudi Arabia	2	0.6	*Oestrus ovis*
Mexico	2	0.6	*Oestrus ovis*
Afghanistan	2	0.6	*Oestrus ovis*
Pakistan	2	0.6	*Oestrus ovis*
Nepal	2	0.6	*Oestrus ovis*
Czech Republic	1	0.3	*Oestrus ovis*
Bulgaria	1	0.3	*Oestrus ovis*
South Africa	1	0.3	*Oestrus ovis*
Australia	1	0.3	*Oestrus ovis*
China	1	0.3	*Oestrus ovis*
Serbia	1	0.3	*Lucilia sericata*
Jamaica	1	0.3	*Oestrus ovis*
South Korea	1	0.3	*Lucilia sericata*
United Kingdom	1	0.3	*Oestrus ovis*
Iraq	1	0.3	*Oestrus ovis*
Bolivia	1	0.3	*Oestrus ovis*
Belgium	1	0.3	*Oestrus ovis*
Barbados	1	0.3	*Oestrus ovis*
Canada	1	0.3	*Dermatobia hominis*
Honduras	1	0.3	*Not identified*
Indonesia	1	0.3	*Chrysomya bezziana*
Japan	1	0.3	*Boettcherisca peregrine*
Morocco	1	0.3	*Oestrus ovis*
Total	312	100.00	

4.2. Clinical features

Among the patients, 43.6% reported a sensation of insects buzzing around their faces or being hit in the eye before the onset of symptoms. In 33% of cases, no identifiable risk factors were associated with the symptoms. It was observed that approximately 9.3% of cases had a history of coexisting with sheep and goats, while 7.7% reported a previous incident of foreign objects entering the eye.

External ophthalmomyiasis caused by *Oestrus ovis* larvae presents with a sudden onset of symptoms such as foreign body sensation, redness, tearing, itching, swelling, irritation, photophobia, burning, and ocular discharge. Bilateral involvement was reported in four cases [25,26]. The slit-lamp examinations revealed highly mobile tiny larvae (1-2 mm long) fleeing from light, conjunctival congestion, hyperemia, chemosis, palpebral edema and hyperemia, epiphora, mucoid discharge, subconjunctival hemorrhage, punctate keratitis, epithelial erosion, corneal abrasion, and palpebral cellulitis. The average number of larvae observed was 7.2 (1-30). *Dermatobia hominis*-caused external ocular myiasis presents with symptoms such as edema of the upper or lower eyelid, edema of the inner or outer canthus of the eye, pain, redness, itching, a sensation of movement inside the lesion, ocular irritation, and serosanguinous discharge. The ophthalmologic examinations revealed edema and palpebral hyperemia, lesions with the fistulous tract, serosanguinous secretion, exudate, and movement of part of the worm at the end of the fistulous tract. Only one larva was observed in most cases, while one case reported three larvae [13].

Lucilia sericata can cause external ophthalmomyiasis, leading to symptoms such as foreign body sensation, pain, ocular discharge, itching, tearing, and redness. During the ophthalmologic examinations, tiny larvae, hyperemic and congestive conjunctiva, chemosis, serous discharge, palpebral hyperemia, and periorbital edema were commonly observed. On average, 12.3 larvae were

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found (ranging from 2 to 19). Similarly, external ophthalmomyiasis caused by *Chrysomyia bezziana* may result in symptoms such as worms emerging through the lesion, edema, fetid secretion, itching, and redness. The ophthalmologic examinations revealed periorbital lesions, worms, conjunctival hyperemia, congestion, and periorbital edema. On average, 16.7 worms were recovered during the examinations (ranging from 1 to 26), as shown in Table 2.

Table 2. General characteristics and clinical pictures of external ophthalmomyiasis cases reported from 2000 to 2022.

Author (year)	Country	Sex	Age	Activity	Cause	Symptoms	Location	Examination	Agent
Weinand FS (2001) [125].	Germany	M	28		Something strikes the eye (autochthonous)	Foreign body sensation	Left	Conjunctival hyperemia, presence of mobile larvae	Oestrus ovis
Emborsky ME (2002) [133].	USA	M	4			Swelling and papules on lower and upper left eyelid	Left	Presence of three papules and a whitish, eyelid edema and hyperemia, mobile foreign body.	*Dermatobia hominis*
Sigauke E. (2003) [10].	USA	F	16	Student		Pain, mucoid discharge	Both eyes	Conjunctival follicular reaction	*No*
Denion E. (2004) [13].	Brazil	M	25				Eyelid (right upper)	Furuncular blepharitis	*Dermatobia hominis*
	French Guiana	F	1				Eyelid (right lower)	Edema and pore near the inner canthus	*Dermatobia hominis*
	French Guiana	F	3				Eyelid (left upper and lower)	Movements observed in the dome-shaped lesion.	*Dermatobia hominis*
	French Guiana	M	39	Gold washer		Pain, writhing sensation	Eyelid (right upper)	Serosanguinous and purulent discharge after larval death.	*Dermatobia hominis*
	French Guiana	M	3			Pruritus		Palpebral edema, pore in the conjunctival fornix	*Dermatobia hominis*
	French Guiana	M	13			Stinging sensation, movements		Intermittently protruding caruncle larvae	*Dermatobia hominis*

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					within the lesion			
	French Guiana		15			Eyelid (left upper)	Dome-shaped lesion, Pore in free margin	*Dermatobia hominis*
	French Guiana		1			Eyelid (right upper)	Erythema and moderate edema around the pore	*Dermatobia hominis*
	French Guiana	M	45			Eyelid (right upper)	Bloody discharge, Edema, Pore in thickened free margin	*Dermatobia hominis*
Gregory AR (2004) [55].	Iraq	M	20	US Soldier	Foreign body sensation, watery eyes, photophobia	Left	Conjunctival congestion, chemosis, periorbital edema and erythema	*Oestrus ovis*
Masoudi M (2004) [59].	Iran	M	15		Foreign body sensation, watery eyes, pruritus, eye redness, swelling		Presence of mobile larvae, chemosis	*Oestrus ovis*
	Iran	M	18		Foreign body sensation, watery eyes, pruritus, eye redness, pain, swelling		Presence of mobile larvae, chemosis	*Oestrus ovis*
	Iran	M	24		Foreign body sensation, watery eyes, pain, swelling, chemosis		Presence of mobile larvae, chemosis	*Oestrus ovis*
	Iran	M	27		Foreign body sensation, watery eyes, pruritus, eye redness, swelling		Presence of mobile larvae, chemosis	*Oestrus ovis*
	Iran	M	34		Foreign body sensation, watery eyes, pruritus, eye redness, swelling		Presence of mobile larvae, chemosis	*Oestrus ovis*

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	Iran	M	36			Watery eyes, pruritus, eye redness, swelling	Presence of mobile larvae, chemosis, rhinorrhea	*Oestrus ovis*
	Iran	F	41			Foreign body sensation, watery eyes, pruritus, eye redness, swelling	Presence of mobile larvae, chemosis	*Oestrus ovis*
	Iran	M	56			Foreign body sensation, watery eyes, pruritus, eye redness, pain, swelling	Presence of mobile larvae, chemosis	*Oestrus ovis*
Levett PN (2004) [53]	Barbados	F	55			Foreign body sensation, rhinorrhea, sneezing	Right	Presence of mobile larvae	*Oestrus ovis*
Ashenhurst M (2004) [52].	Canada	F	50	Tourist traveled to Belize	Insect bite in the eye	Pain, periorbital erythema, edema of the lower eyelid	Left	Fistulous tract of erythema with periorbital edema around the lower eyelid region.	*Dermatobia hominis*
Dono M (2005) [42]	Italy	M			Insect flying around the face	Foreign body sensation, pruritus, pain, burning eye			*Oestrus ovis*
	Italy	M			A sensation of water drop entry	Foreign body sensation, pruritus, pain, burning eye			*Oestrus ovis*
	Italy	M				Foreign body sensation, pruritus, pain, burning eye			*Oestrus ovis*
Huynh N (2005) [134].	USA	M	60		History of palpebral trauma	Pain, eye redness, swelling	Right	Upper and lower eyelid edema with erythema and a 1.5 mm round ulceration in the external canthal region.	*Phaenicia Lucilia*

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Verstrynge K (2005) [54].	Belgium	F	26	Tourist in Greece		Foreign body sensation, watery eyes	Right	Congested conjunctiva, presence of mobile larvae.	*Oestrus ovis*
Miura M (2005) [50].	Japan	M	72		Unconscious patient	Presence of larvae	Left	Conjunctival hyperemia, hemorrhage with discharge	*Boettcheri sca peregrine*
Beltran FM (2006) [135].	Peru	M	50	Fisherma n	Come from cattle-raising areas	Foreign body sensation, eye redness, eyelid edema, photophobia, decreased visual acuity	Left		*Oestrus ovis*
	Peru	F	67	Laundres s	Come from cattle-raising areas	Foreign body sensation, eye redness, eyelid edema, chemosis, decreased visual acuity	Right		*Oestrus ovis*
	Peru	M	11	Student	Come from cattle-raising areas	Foreign body sensation, eye redness, eyelid edema, photophobia	Right		*Oestrus ovis*
Caça I. (2006) [85].	Turkey	F	8	Farmer's daughter	An ulcerated area on the lateral canthus and zygomatic area	An outgrowth of maggots from the wound around the eye	Right	Lower eyelid and lower palpebral conjunctiva involvement and destruction.	*Chrysomy a bezziana*
Ali A (2006) [136]	Pakistan	F	49			Pruritus, eye redness, photophobia	Left	Follicular conjunctivitis, hyperemia, mild visual loss.	*Family Oestridae*
	Pakistan	M	19		Get hit by a fly	Foreign body sensation, eye redness		Presence of mobile larvae	*Oestrus ovis*
Wakamats u TH (2006) [137].	Brazil	M	11			Pruritus, pain, edema on the inner cantus	Right	Periorbital edema, small erythematous lesion (inner canthus) with a well-defined	*Dermatob ia hominis*

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								spot in the center	
Bali J (2007) [76]	India	M	50	Manual laborer	Trauma to the eyelid	Swelling, ulceration	Eyelid (right lower)	Presence of maggots, preseptal cellulitis, ulceration, induration, bloody discharge	*No*
Price KM (2007) [131].	USA	F	5			Swelling	Eyelid (left upper)	Eyelid edema and hyperemia, presence of small opening with clear discharge.	*Dermatobia hominis*
Misra S (2008) [34]	India	F	34	Housewife	Get hit by a fly	Foreign body sensation, watery eyes, eye redness	Right	Conjunctival congestion, presence of mobile larvae, eyelid edema	*Oestrus ovis*
	India	M	4				Left	Presence of a mobile larvae	*Oestrus ovis*
	India	M	40	Farmer	Get hit by a fly		Left		*Oestrus ovis*
	India	F	8	Student			Left		*Oestrus ovis*
	India	F	15	Student	Get hit by a fly		Left		*Oestrus ovis*
	India	M	29	Pastor	Get hit by a fly		Right		*Oestrus ovis*
	India	M	30	Farmer	Get hit by a fly		Right	Presence of mobile larvae	*Oestrus ovis*
	India	M	16	Pastor	Get hit by a fly		Both eyes		*Oestrus ovis*
	India	F	21	Teacher			Left		*Oestrus ovis*
	India	M	26	Farmer	Get hit by a fly		Right		*Oestrus ovis*
	India	F	29	Farmer	Get hit by a fly		Right		*Oestrus ovis*
	India	M	18	Pastor			Left	Presence of mobile larvae	*Oestrus ovis*
	India	F	56	Farmer	Get hit by a fly		Left		*Oestrus ovis*
Dunbar J. (2008) [97].	Afghanistan	F	29	Nurse	Get hit by a fly	Foreign body sensation, watery eyes, pain, burning eye		Presence of mobile larvae	*Oestrus ovis*

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Eyigör H. (2008) [87].	Turkey	M	33	Research Assistant	Contact with sheep	Mobile foreign body sensation	Right	Presence of mobile larvae	*Oestrus ovis*
Stacey MJ (2008) [122].	Afghanistan	M	18	UK Soldier		Mobile foreign body sensation, irritation	Left	Presence of mobile larvae, follicular reaction and diffuse injection of the conjunctiva	*Oestrus ovis*
Thabit AM (2008) [77].	Jordan (32) Jordan (17)	M 65% (32) F 35% (17)	31.6			Foreign body sensation, watery eyes, pruritus, eye redness, swelling	Right (28), Left (21)	Conjunctival hyperemia, presence of mobile larvae, chemosis, watery eyes, mild to severe conjunctivitis, eyelid edema, pruritus, pain	*No*
Alhady M (2008) [51].	Indonesia	M	9		Co-infestation otomiasis-ophthalmomyiasis	Red eye	Right	A breach in the superonasal bulbar conjunctiva and a live maggot deep in the wound.	*Chrysomya bezziana*
Kemmanu V. (2009) [27].	India	M	15	Farmer	A fly landed on the eye	Foreign body sensation	Left	Conjunctival congestion, sub-conjunctival hemorrhage, mucoid discharge, punctate keratitis.	*Oestrus ovis*
Thakur K. (2009) [2].	India	F	17	Student	Exposed to a dust storm	Foreign body sensation, watery eyes, irritation	Right	Congested conjunctiva, presence of small transparent worms	*Oestrus ovis*
Pandey A. (2009) [67].	India	M	25	Farmer	Something entered the eye while resting under a tree.	Foreign body sensation, watery eyes, burning eye	Right	Congestive conjunctiva, presence of mobile larvae, watery eyes	*Oestrus ovis*
Rivasi F. (2009) [33].	Italy	M	54	Office Clerk	Foreign body sensation while walking	Watery eyes, photophobia, irritation	Left	Conjunctiva hyperemia, watery exudate,	*Oestrus ovis*

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								presence of small transparent bodies.	
Jenzeri S. (2009) [36].	Tunisia	M	77	Farmer		Foreign body sensation, eye redness, pain, photophobia	Right	Congested conjunctiva, presence of mobile larvae, diffuse stromal corneal edema, various sub-epithelial opacities	*Oestrus ovis*
Cucera A (2009) [94].	Germany	M	30	Tourist in Corsica	Contact with flies	Foreign body sensation, watery eyes, eye redness, swelling (eyelids)	Left	Conjunctival hyperemia and congestion, presence of mobile larvae, chemosis, palpebral edema	*Oestrus ovis*
	Germany	F	30	Tourist in Corsica	Contact with flies	Foreign body sensation, watery eyes, eye redness, swelling (eyelids)	Left	Conjunctival hyperemia and congestion, presence of mobile larvae, chemosis, palpebral edema	*Oestrus ovis*
Kuk S (2009) [88]	Turkey	M	40		Get hit by a fly	Foreign body sensation, eye redness	Right	Presence of mobile larvae, chemosis, cornea with punctate keratitis	*Oestrus ovis*
Abuelhssan AA (2010) [138].	Oman	M	9		Get hit by a fly	Foreign body sensation, watery eyes	Right	Congested conjunctiva, presence of five mobile larvae, watery eyes	*Oestrus ovis*
Anane S (2010) [1]	Tunisia	M	6	Student	Get hit by a fly	Foreign body sensation, watery eyes, pruritus, photophobia		Conjunctival hyperemia, presence of mobile larvae	*Oestrus ovis*
	Tunisia	M	30	Technician	Get hit by a fly	Foreign body sensation,		Conjunctival hyperemia,	*Oestrus ovis*

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						watery eyes, pruritus, photophobia	presence of mobile larvae	
	Tunisia	M	63	Retiree	Get hit by a fly	Foreign body sensation, watery eyes, pruritus, photophobia	Conjunctival hyperemia, presence of mobile larvae	*Oestrus ovis*
	Tunisia	M	20	Worker	Get hit by a fly	Foreign body sensation, watery eyes, pruritus, photophobia	Conjunctival hyperemia, presence of mobile larvae	*Oestrus ovis*
	Tunisia	F	17	Student	Get hit by a fly	Foreign body sensation, watery eyes, pruritus, photophobia	Conjunctival hyperemia, presence of mobile larvae	*Oestrus ovis*
	Tunisia	M	41	Banker	Get hit by a fly	Foreign body sensation, watery eyes, pruritus, photophobia	Conjunctival hyperemia, presence of mobile larvae	*Oestrus ovis*
	Tunisia	M	34	Merchant	Get hit by a fly	Foreign body sensation, watery eyes, pruritus, photophobia	Conjunctival hyperemia, presence of mobile larvae	*Oestrus ovis*
	Tunisia	M	16	Artisan	Get hit by a fly	Foreign body sensation, watery eyes, pruritus, photophobia	Presence of mobile larvae, chemosis	*Oestrus ovis*
	Tunisia	M	8	Student	Get hit by a fly	Foreign body sensation, watery eyes, pruritus, photophobia	Conjunctival hyperemia, presence of mobile larvae	*Oestrus ovis*
	Tunisia	F	45	Housewife	Get hit by a fly	Foreign body sensation, watery eyes, pruritus, photophobia	Presence of mobile larvae, chemosis	*Oestrus ovis*
	Tunisia	M	60	Tourist	Get hit by a fly	Foreign body sensation, watery eyes, pruritus, photophobia	Conjunctival hyperemia, presence of mobile larvae	*Oestrus ovis*
Smillie I (2010) [56].	United Kingdom	F	51	Tourist to Morocco		Foreign body sensation, pruritus, eye congestion	Right	Presence of larvae	*Oestrus ovis*

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Khurana S. (2010) [139].	India	F	30			Foreign body sensation, watery eyes	Right	Presence of a mobile larvae	*Oestrus ovis*
	India	F	17		Get hit by a fly	Foreign body sensation, watery eyes	Right	Presence of a mobile larvae	*Oestrus ovis*
Arslan F (2010) [140].	Turkey (Istanbul)	M	25	Medical student	Insect flying around the face	Pruritus, eye redness, pain, burning eye	Left	Conjunctival hyperemia, presence of mobile larvae, watery eyes	*Oestrus ovis*
Sreejith RS (2010) [75].	India	M	35		Dust entered the eye	Watery eyes, eye redness, swelling (eyelid), irritation	Right	Presence of mobile larvae, periorbital and palpebral edema, mucous secretion, conjunctival hemorrhages	*Oestrus ovis*
Abdellatif MZ (2011) [14].	Libya	F			Insect flying around the face	Eye redness		Presence of larvae	*Oestrus ovis*
	Libya	F			Insect flying around the face	Eye redness		Presence of larvae	*Oestrus ovis*
	Libya	F			Insect flying around the face	Eye redness		Presence of larvae	*Oestrus ovis*
	Libya	F			Insect flying around the face	Eye redness		Presence of larvae	*Oestrus ovis*
	Libya	F			Insect flying around the face	Eye redness		Presence of larvae	*Oestrus ovis*
	Libya	F			Insect flying around the face	Eye redness		Presence of larvae	*Oestrus ovis*
	Libya	F			Insect flying around the face	Eye redness		Presence of larvae	*Oestrus ovis*
	Libya	M			Insect flying around the face	Eye redness		Presence of larvae	*Oestrus ovis*
	Libya	M			Insect flying around the face	Eye redness		Presence of larvae	*Oestrus ovis*
	Libya	M			Insect flying around the face	Eye redness		Presence of larvae	*Oestrus ovis*

	Libya	M		Insect flying around the face	Eye redness		Presence of larvae	*Oestrus ovis*
	Libya	M		Insect flying around the face	Eye redness		Presence of larvae	*Oestrus ovis*
	Libya	M		Insect flying around the face	Eye redness		Presence of larvae	*Oestrus ovis*
	Libya	M		Insect flying around the face	Eye redness		Presence of larvae	*Oestrus ovis*
	Libya	M		Insect flying around the face	Eye redness		Presence of larvae	*Oestrus ovis*
	Libya	M		Insect flying around the face	Eye redness		Presence of larvae	*Oestrus ovis*
	Libya	M		Insect flying around the face	Eye redness		Presence of larvae	*Oestrus ovis*
	Libya	M		Insect flying around the face	Eye redness		Presence of larvae	*Oestrus ovis*
	Libya	M		Insect flying around the face	Eye redness		Presence of larvae	*Oestrus ovis*
	Libya	M		Insect flying around the face	Eye redness		Presence of larvae	*Oestrus ovis*
	Libya	M		Insect flying around the face	Eye redness		Presence of larvae	*Oestrus ovis*
Yar K. (2011) [86].	Turkey	F	43		Foreign body sensation, pruritus, eye redness, pain	Right	Conjunctival hyperemia, presence of mobile larvae, eyelid edema and hyperemia (right)	*Oestrus ovis*
	Turkey	M	21		Eye redness, eye burning	Right	Conjunctival hyperemia, presence of mobile larvae	*Oestrus ovis*
Ramirez-Miranda (2011) [15].	Mexico	M	40	Something hit in the face	Foreign body sensation, watery eyes, pruritus, eye redness	Both eyes	Presence of a mobile larvae	*Oestrus ovis*

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Chakraborti C (2011) [141].	India	M	35	Merchant	Living with animals	Pruritus, burning eye	Left	Conjunctival congestion, presence of mobile larvae	*Oestrus ovis*
	India	M	24	Shoemaker	Living with animals	Watery eyes, eye redness, irritation	Left	Conjunctival congestion, presence of mobile larvae	*Oestrus ovis*
Singh PK. (2012) [25].	India	M	11			Foreign body sensation, watery eyes, pruritus	Both eyes	Conjunctival hyperemia, presence of mobile larvae, chemosis, palpebral edema	*Oestrus ovis*
	India	M	45	Farmer		Foreign body sensation, watery eyes, pruritus	Right	Conjunctival hyperemia, presence of mobile larvae, chemosis, palpebral edema	*Oestrus ovis*
	India	M	25	Farmer		Foreign body sensation, watery eyes, pruritus	Right	Conjunctival hyperemia, presence of mobile larvae, chemosis, palpebral edema	*Oestrus ovis*
Shankar MK (2012) [66].	India	M	50	Farmer	Something entered the eye while working	Foreign body sensation, watery eyes, eye redness, pain	Left	Congested conjunctiva, presence of mobile larvae, watery eyes	*Oestrus ovis*
Vijayalekshmi S. (2013) [63].	India	F	25	Veterinary	Something entered the eye	Foreign body sensation, watery eyes, burning eye	Left	Congested conjunctiva, watery eyes	*Oestrus ovis*
Akdemir MO (2013) [24].	Turkey	F	18			Foreign body sensation, watery eyes, eyelid edema.		Conjunctival hyperemia, chemosis, eyelid edema, sub-conjunctival hemorrhage.	*Oestrus ovis*
	Turkey	F	23		Exposure to flies	Foreign body sensation, watery eyes, eye redness		Conjunctival hyperemia	*Oestrus ovis*
	Turkey	M	12			Foreign body sensation,		Conjunctival hyperemia, chemosis	*Oestrus ovis*

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						watery eyes, eye redness		
	Turkey	F	45		Exposure to flies	Foreign body sensation, watery eyes, eye redness	Conjunctival hyperemia, chemosis	*Oestrus ovis*
	Turkey	M	61		Exposure to flies	Foreign body sensation, watery eyes, eye redness, eyelid edema	Conjunctival hyperemia, chemosis, palpebral edema.	*Oestrus ovis*
	Turkey	M	28		Exposure to flies	Foreign body sensation, watery eyes, eye redness, eyelid edema	Conjunctival hyperemia, chemosis, palpebral edema, punctate epithelial erosions.	*Oestrus ovis*
	Turkey	M	17			Foreign body sensation, watery eyes, eye redness	Conjunctival hyperemia, chemosis	*Oestrus ovis*
	Turkey	M	13			Foreign body sensation, watery eyes, eye redness	Conjunctival hyperemia, chemosis	*Oestrus ovis*
	Turkey	F	15		Exposure to flies	Foreign body sensation, watery eyes, eye redness, eyelid edema	Conjunctival hyperemia, chemosis, palpebral edema, punctate epithelial erosions	*Oestrus ovis*
	Turkey	F	48		Exposure to flies	Foreign body sensation, watery eyes, eye redness, eyelid edema	Conjunctival hyperemia, chemosis, eyelid edema.	*Oestrus ovis*
Sucilathangam G. (2013) [35].	India	M	25	Farmer		Foreign body sensation, watery eyes, pruritus	Conjunctival hyperemia, watery eyes, eyelid edema, chemosis, rhinorrhea	*Oestrus ovis*
	India	M	28	Farmer		Foreign body sensation, watery eyes, pruritus, pain	Conjunctival hyperemia, chemosis, eyelid edema, watery eyes	*Oestrus ovis*

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	India	M	42	Farmer		Foreign body sensation, pruritus, pain, burning eye	Chemosis, watery eyes, eyelid edema	*Oestrus ovis*
	India	M	47	Farmer		Foreign body sensation, watery eyes, pruritus, burning eye	Conjunctival hyperemia, chemosis, watery eyes, palpebral edema	*Oestrus ovis*
	India	M	35	Farmer		Foreign body sensation, watery eyes, pruritus	Conjunctival hyperemia, chemosis, watery eyes, palpebral edema	*Oestrus ovis*
	India	M	25	Farmer		Foreign body sensation, watery eyes, pruritus, burning eye	Conjunctival hyperemia, chemosis, eyelid edema, rhinorrhea	*Oestrus ovis*
	India	F	30	Farmer		Foreign body sensation, watery eyes, pruritus, burning eye	Conjunctival hyperemia, chemosis, watery eyes, palpebral edema	*Oestrus ovis*
	India	M	65	Farmer		Foreign body sensation, watery eyes, pruritus, pain, burning eye	Conjunctival hyperemia, chemosis, watery eyes, palpebral edema	*Oestrus ovis*
	India	M	35	Farmer		Foreign body sensation, watery eyes, pruritus, pain, burning eye	Conjunctival hyperemia, watery eyes, eyelid edema, chemosis, rhinorrhea	*Oestrus ovis*
	India	F	26	Farmer		Foreign body sensation, pruritus, pain, burning eye	Conjunctival hyperemia, chemosis, watery eyes, eyelid edema	*Oestrus ovis*
Graffi S. (2013) [114].	Israel	M	91	Elderly handicapped	Patient hospitalized with underlying disease		Both eyes	Congested conjunctiva, presence of a mobile larvae in both cul-de-sacs,	*Sarcophaga argyrostoma*

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							mucopurulent discharge.	
Taormina YA. (2013) [106].	USA	F	1		Eye redness, swelling in the periorbital region	Left	Eyelid edema, erythema, and edema (upper and lower) with a punctate sinus tract in the upper eyelid draining serosanguinous material.	*Dermatobia hominis*
Tomy RM (2013) [9].	India	M	70	Elderly with underlying disease	Involvement of periorbital tissues due to malignant disease	Presence of foul-smelling ulcers in the wall of the eye, riddled with maggots.	Right	Eyelids thickened and inflamed, ulcerative cavities filled with maggots, exposure keratitis.	*Musca domestica*
Choudhary P. (2013) [61].	India	F	16		Ram piece injury.	Foreign body sensation, watery eyes, mild conjunctivitis	Presence of larvae, conjunctivitis	*Oestrus ovis*
	India	F	14		Get hit by a fly	Foreign body sensation, watery eyes, pruritus	Presence of larvae, conjunctivitis (mild) with mucoid discharge	*Oestrus ovis*
	India	F	18	Peasant	Foreign body sensation while working	Foreign body sensation, watery eyes, eye redness	Presence of larvae, conjunctivitis (mild)	*Oestrus ovis*
	India	M	65		Get hit by a fly	Watery eyes, eye redness, pain, mucopurulent discharge	Presence of larvae, chemosis, congestion, punctate sub-conjunctival hemorrhages	*Oestrus ovis*
	India	F	16		Get hit by a fly	Foreign body sensation, eye redness, pain	Presence of larvae, conjunctivitis (mild)	*Oestrus ovis*
	India	F	25	Peasant	Foreign body sensation while working	Foreign body sensation, watery eyes, eye redness	Presence of larvae, conjunctivitis	*Oestrus ovis*

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	India	F	18		Get hit by a fly	Watery eyes, eye redness, pain		Presence of larvae, conjunctivitis	*Oestrus ovis*
Carrillo I. (2013) [142].	Spain	M	26	Hiker	Get hit by a fly	Foreign body sensation	Left	Presence of larvae	*Oestrus ovis*
	Spain	M	34		Get hit by a fly	Watery eyes, pruritus	Right	Presence of larvae in the conjunctival fornix	*Oestrus ovis*
	Spain	M	22			Mobile foreign body sensation, eye redness	Left	Presence of larvae in the conjunctival fornix	*Oestrus ovis*
Pather S (2013) [48]	South Africa	M	30	Construction worker		Eye redness, pain	Left	Conjunctival hyperemia, presence of mobile larvae, chemosis	*Oestrus ovis*
Gholamhossein Y (2013) [37].	Iran	M		Farmer living in a rural region	Travel to desert regions or living with sheep	Foreign body sensation, eye redness, eyelid edema		Conjunctival hyperemia, palpebral edema	*Oestrus ovis*
	Iran	M		Farmer living in a rural region	Travel to desert regions or living with sheep	Foreign body sensation, eye redness, eyelid edema		Conjunctival hyperemia, palpebral edema	*Oestrus ovis*
	Iran	M		Farmer living in a rural region	Travel to desert regions or living with sheep	Foreign body sensation, eye redness, eyelid edema		Conjunctival hyperemia, palpebral edema	*Oestrus ovis*
	Iran	M		Farmer living in a rural region	Travel to desert regions or living with sheep	Foreign body sensation, eye redness, eyelid edema		Conjunctival hyperemia, chemosis, a viscous pattern of discharge	*Oestrus ovis*
	Iran	M		Farmer living in a rural region	Travel to desert regions or living with sheep	Foreign body sensation, eye redness, eyelid edema		Conjunctival hyperemia, chemosis, a viscous pattern of discharge	*Oestrus ovis*
	Iran	M		Farmer living in a rural region	Travel to desert regions or living with sheep	Foreign body sensation, eye redness, eyelid edema		Conjunctival hyperemia, chemosis, a viscous pattern of discharge	*Oestrus ovis*

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	Iran	M	Farmer living in a rural region	Travel to desert regions or living with sheep	Foreign body sensation, eye redness, eyelid edema	Conjunctival hyperemia, chemosis, a viscous pattern of discharge	*Oestrus ovis*
	Iran	M	Farmer living in a rural region	Travel to desert regions or living with sheep	Foreign body sensation, eye redness, eyelid edema	Conjunctival hyperemia, chemosis, a viscous pattern of discharge	*Oestrus ovis*
	Iran	M	Farmer living in a rural region	Travel to desert regions or living with sheep	Foreign body sensation, eye redness, eyelid edema	Conjunctival hyperemia, chemosis, a viscous pattern of discharge	*Oestrus ovis*
	Iran	M	Farmer living in a rural region	Travel to desert regions or living with sheep	Foreign body sensation, eye redness, eyelid edema	Conjunctival hyperemia, chemosis, a viscous pattern of discharge	*Oestrus ovis*
	Iran	M	Farmer living in a rural region	Travel to desert regions or living with sheep	Foreign body sensation, eye redness, eyelid edema	Conjunctival hyperemia, chemosis, a viscous pattern of discharge	*Oestrus ovis*
	Iran	M	Farmer living in a rural region	Travel to desert regions or living with sheep	Foreign body sensation, eye redness, eyelid edema	Conjunctival hyperemia, chemosis, a viscous pattern of discharge	*Oestrus ovis*
	Iran	M	Farmer living in a rural region	Travel to desert regions or living with sheep	Foreign body sensation, eye redness, eyelid edema	Conjunctival hyperemia, chemosis, a viscous pattern of discharge	*Oestrus ovis*
	Iran	M	Farmer living in a rural region	Travel to desert regions or living with sheep	Foreign body sensation, eye redness, eyelid edema	Conjunctival hyperemia, chemosis, a viscous pattern of discharge	*Oestrus ovis*
	Iran	M	Farmer living in a rural region	Travel to desert regions or	Foreign body sensation, eye redness, eyelid edema	Conjunctival hyperemia, chemosis, a viscous	*Oestrus ovis*

					living with sheep			pattern of discharge	
	Iran	M		Farmer living in a rural region	Travel to desert regions or living with sheep	Foreign body sensation, eye redness, eyelid edema		Conjunctival hyperemia, chemosis, a viscous pattern of discharge	*Oestrus ovis*
	Iran	M		Farmer living in a rural region	Travel to desert regions or living with sheep	Foreign body sensation, eye redness, eyelid edema		Conjunctival hyperemia, chemosis, a viscous pattern of discharge	*Oestrus ovis*
	Iran	M		Farmer living in a rural region	Travel to desert regions or living with sheep	Foreign body sensation, eye redness, eyelid edema		Conjunctival hyperemia, chemosis, a viscous pattern of discharge	*Oestrus ovis*
Neimer SA (2014) [29].	Israel	M	27		Get hit by an insect	Watery eyes, pain, eye burning	Left	Hyperemia, swollen and erythematous palpebral, watery eyes	*Oestrus ovis*
	Israel	M	17		Get hit by a fly (face)	Mobile foreign body sensation, irritation	Left	Hyperemia, swollen and erythematous palpebral, watery eyes	*Oestrus ovis*
Ranjan R. (2014) [32].	Oman	M	72	Homeless person	Trauma to the eyelid	Pain, ulceration, discomfort	Eyelid (left upper)	Ulceration, erythema, and edema of the periorbital tissues, necrosis upper eyelid with numerous maggots.	*No*
Istek Ş. (2014) [78].	Turkey	M	30	Farmer	Contact with sheep	Foreign body sensation	Right	Conjunctival hyperemia, presence of mobile larvae, serous discharge	*Oestrus ovis*
	Turkey	F	26		A fly landed on the eye	Mobile foreign body sensation	Right	Conjunctival hyperemia, presence of mobile larvae, mucopurulent discharge,	*Oestrus ovis*

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								palpebral cellulitis	
	Turkey	M	10	Farmer	A fly landed on the eye	Red eye		Presence of mobile larvae in the lacrimal meniscus	*Oestrus ovis*
Kalezic T. (2014) [17].	Serbia	F	87	Disabled elderly woman	Severe neurological damage with predisposing factors		Left	Presence of larvae on the conjunctival surface	*Lucilia sericata*
Akçakaya AA (2014) [84].	Turkey	M	17	Student	A fly landed on the eye	Mobile foreign body sensation, watery eyes, pain, irritation	Left	Conjunctival hyperemia, presence of mobile larvae, eyelid edema (left)	*Oestrus ovis*
Calışkan S (2014) [26].	Turkey	M	17			Watery eyes, pruritus, eye redness	Both eyes	Conjunctival hyperemia, presence of mobile larvae, eyelid edema (bilateral)	*Oestrus ovis*
	Turkey	F	25		Get hit by a fly	Foreign body sensation, watery eyes	Both eyes	Conjunctival hyperemia, presence of mobile larvae, bilateral conjunctival congestion	*Oestrus ovis*
	Turkey	M	31	Merchant	Get hit by a fly	Foreign body sensation, watery eyes	Both eyes	Presence of mobile larva, chemosis (bilateral)	*Oestrus ovis*
Al-Amry M (2014) [143].	Saudi Arabia	M	50		Went through a sheep farming area	Mobile foreign body sensation, watery eyes, eye redness	Right	Conjunctival chemosis, presence of mobile larvae	*Oestrus ovis*
Garcia-Guerrero J (2014) [16].	Mexico	F	16	Student	Get hit by an insect	Foreign body sensation, eye redness, pain	Left	Congested conjunctivitis, presence of mobile larvae	*Oestrus ovis*
Uslu Hakan (2014) [60].	Libya	M	20			Eye redness, eye burning	Left	Conjunctival hyperemia, presence of mobile larvae, chemosis	*Oestrus ovis*
Murga H (2014) [58].	Bolivia	F	35		Something entered the eye	Mobile foreign body sensation, pruritus	Left	Presence of mobile larvae	*Oestrus ovis*

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Alameri OH (2014) [39].	Jordan	M	25	Farmer	Foreign body sensation	Foreign body sensation, pain, irritation	Right	Presence of mobile larvae, watery eyes, palpebral edema and hyperemia	*Oestrus ovis*
Bonzon L. (2015) [144].	France	F	45	Teacher	Get hit by a fly	Pruritus, irritation	Right	Presence of larvae	*Oestrus ovis*
	France	F	67	Farmer	Get hit by an insect	Pain			*Oestrus ovis*
	France	F	43	Nurse	Trauma to the eye (fly)	Foreign body sensation			*Oestrus ovis*
	France	M	28	Mason	Trauma to the eye.	Pain	Left		*Oestrus ovis*
Dokur M. (2015) [82].	Turkey	M	57			Pruritus, eye redness	Left	Conjunctival hyperemia, presence of mobile larvae	*Oestrus ovis*
Choi W (2015) [22]	South Korea	M	72	Farmer	No predisposing factors	Foreign body sensation, watery eyes, eye redness, pain	Left	Left periorbital edema, erythema of the left eyelid, and small larvae in the conjunctival pouch.	*Lucilia sericata*
Berrozpe-Villabona C. (2015) [145].	Spain	M	50	Tourist	Went on vacation to a rural area	Mobile foreign body sensation, watery eyes, pruritus	Left	Presence of mobile larvae, watery eyes, congested bulbar conjunctiva	*Oestrus ovis*
Sundu C (2015) [79]	Turkey	M	13		Foreign body hit the eye while passing by a flock of sheep	Watery eyes, pruritus, eyelid edema	Left	Presence of mobile larvae in the palpebral conjunctiva	*Oestrus ovis*
	Turkey	M	21		Foreign body hit the eye	Watery eyes, eye redness, blurred vision	Right	Presence of mobile larvae in the palpebral and bulbar conjunctivae.	*Oestrus ovis*
	Turkey	M	55	Pastor	Larvae removed from the eye (a week earlier).	Watery eyes, eye redness	Right	Presence of mobile larvae in the palpebral and bulbar conjunctivae.	*Oestrus ovis*

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Santé Fernandez (2015) [146].	Spain (Canary Islands)	F	43		Contact with flies	Foreign body sensation, eye redness, pain	Right	Presence of a mobile larvae	*Oestrus ovis*
Naimer SA (2015) [30]	Israel	M	27		Contact with flies	Watery eyes, pain	Left	Presence of larvae, watery eyes, eyelid edema and hyperemia	*Oestrus ovis*
Nene AS (2015) [74]	India	F	42	Poverty and chronic alcoholism	A wound in the inner canthus	Pruritus, edema, foul-smelling discharge, presence of worms	Right	Presence of mobile larvae, periorbital edema, conjunctival vascular ingurgitation, inner canthal lesion	*Chrysomya bezziana*
Usta G (2015) [40]	Turkey	F	4		Dust entered the eye	Watery eyes, pruritus, eye redness, irritation	Right	Conjunctival hyperemia, presence of mobile larvae, watery eyes, eyelid edema	*Oestrus ovis*
	Turkey	F	50	Pastor	Get hit by a fly	Watery eyes, pruritus, eye redness, irritation	Right	Conjunctival hyperemia, presence of mobile larvae, watery eyes, eyelid edema	*Oestrus ovis*
	Turkey	F	45	Farmer	Get hit by a fly	Watery eyes, pruritus, eye redness, irritation	Left	Conjunctival hyperemia, presence of mobile larvae, watery eyes, eyelid edema	*Oestrus ovis*
	Turkey	F	49	Pastor	Get hit by a fly	Watery eyes, pruritus, eye redness, irritation	Right	Conjunctival hyperemia, presence of mobile larvae, watery eyes, eyelid edema	*Oestrus ovis*
	Turkey	F	60	Farmer	Get hit by a fly	Watery eyes, pruritus, eye redness, irritation	Right	Conjunctival hyperemia, presence of mobile larvae, watery eyes, eyelid edema	*Oestrus ovis*
	Turkey	M	18	Student	Get hit by something	Watery eyes, pruritus, eye redness, irritation	Left	Conjunctival hyperemia, presence of mobile larvae,	*Oestrus ovis*

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								watery eyes, eyelid edema	
	Turkey	M	41	Worker	Get hit by something	Watery eyes, pruritus, eye redness, irritation	Right	Conjunctival hyperemia, presence of mobile larvae, watery eyes, eyelid edema	*Oestrus ovis*
	Turkey	M	19	Student	Get hit by something	Watery eyes, pruritus, eye redness, irritation	Right	Conjunctival hyperemia, presence of mobile larvae, watery eyes, eyelid edema	*Oestrus ovis*
	Turkey	M	17	Student	Get hit by a fly	Watery eyes, pruritus, eye redness, irritation	Right	Conjunctival hyperemia, presence of mobile larvae, watery eyes, eyelid edema	*Oestrus ovis*
	Turkey	F	33	Housewife	Get hit by something	Watery eyes, pruritus, eye redness, irritation	Left	Conjunctival hyperemia, presence of mobile larvae, watery eyes, eyelid edema	*Oestrus ovis*
	Turkey	M	21	Student	Get hit by a fly	Watery eyes, pruritus, eye redness, irritation	Left	Conjunctival hyperemia, presence of mobile larvae, watery eyes, eyelid edema	*Oestrus ovis*
	Turkey	M	52	Shopkeeper	Get hit by a fly	Watery eyes, pruritus, eye redness, irritation	Right	Conjunctival hyperemia, presence of mobile larvae, watery eyes, eyelid edema	*Oestrus ovis*
Vogt R (2015) [147].	Germany	M	26	Tourist to Croatia		Foreign body sensation, pruritus	Left	Conjunctival hyperemia and congestion, presence of mobile larvae, chemosis	*Oestrus ovis*
Pal N. (2016) [28].	India	F	36		Dust entered the eye	Foreign body sensation, watery eyes, eye redness	Left	Bulbar and palpebral conjunctiva hyperemia and tiny mobile white bodies.	*Oestrus ovis*

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Alsaif N. (2016) [116].	USA	F	10		Visit a farm	Swelling of the eyelid	Eyelid (right upper and lower)	Eyelid edema (right upper and lower), periorbital edema, conjunctival chemosis, cutaneous opening located adjacent to the lateral canthus.	*Dermatobia hominis*
Özyol P (2016) [80].	Turkey	F	45		While cutting fruit from a tree	Foreign body sensation, eye redness, pain	Right	Conjunctival hyperemia, presence of mobile larvae, mucopurulent discharge in the cul-de-sacs	*Oestrus ovis*
	Turkey	F	37		Get hit by a fly	Foreign body sensation, watery eyes, eye redness	Right	Conjunctival hyperemia, presence of mobile larvae, eyelid edema, punctate keratitis	*Oestrus ovis*
	Turkey	M	17			Eye redness, pain	Right	Conjunctival hyperemia, presence of mobile larvae, small conjunctival hemorrhages	*Oestrus ovis*
Albaroudi N (2016) [49].	Morocco	M	28		Contact with flies	Foreign body sensation, watery eyes, pruritus, eye redness		Conjunctival hyperemia, presence of mobile larvae	*Oestrus ovis*
Rizvi SW (2016) [73].	India	M	60	Homeless person	History of right eye evisceration one year before.	Painful swelling around the eyes, scalp with discharge, burning eye	Both eyes	Left eye only with senile cataract	*Musca domestica*
Norouzi R. (2017) [18].	Iran	M	78	Farmer	Previous retinal surgery with predisposing factors	Foreign body sensation, pruritus, pain, eye discharge,	Right	Conjunctival hyperemia and congestion, presence of mobile larvae,	*Lucilia sericata*

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						presence of worms		moderate discharge, palpebral edema	
Sen M. (2017) [115]	India	F	52	Farmer	Something entered the eye	Watery eyes, pain, eye burning	Right	Congested conjunctiva, presence of mobile larvae, watery eyes	*Oestrus ovis*
	India	M	75	Farmer	Soil particles hit both eyes	Watery eyes, eye redness, pain	Both eyes	Congested conjunctiva, presence of mobile larvae, watery eyes	*Oestrus ovis*
Villeda S. (2017) [57].	Hondura s	F	8			Foreign body sensation, eyelid edema, conjunctival hyperemia, yellowish discharge	Left	Conjunctival hyperemia, presence of mobile larvae, biparpebral edema, purulent discharge	*No*
Jenkins KS. (2018) [45].	Australia	M	20	Tourist		Watery eyes, pain, photophobia		Conjunctival hyperemia, presence of three larvae, corneal abrasion	*Oestrus ovis*
Gupta PC (2018) [64].	India	M	38	Farmer	Exposure to manure	Foreign body sensation	Left	Congested conjunctivae, palpebral edema	*Musca spp.*
Basmaciya n L. (2018) [102].	France	M	19	Farmer	Trauma to the eye (fly)	Mobile foreign body sensation, pain	Right	Conjunctival hyperemia and congestion, presence of mobile larvae	*Oestrus ovis*
Velev V. (2018) [44].	Bulgaria	F	61		Get hit by an insect	Foreign body sensation, watery eyes, conjunctival hyperemia	Left	Conjunctival hemorrhage, presence of three mobile larvae, eyelid edema (lower)	*Oestrus ovis*
Zhang A. (2018) [46]	China	M	30	Vehicle Inspector	Foreign body sensation while closing the door of a farm vehicle.	Foreign body sensation, watery eyes, pruritus	Right	Conjunctival hyperemia, presence of mobile larvae in the tarsal and bulbar conjunctiva.,	*Oestrus ovis*

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								petechial hemorrhages	
Sharma K. (2018) [148].	Saudi Arabia	M	32		Exposed to a dust storm	Foreign body sensation, watery eyes, eye redness, rhinorrhea	Left	Congested conjunctiva, presence of larvae, eyelid edema, photophobia, reduced palpebral aperture	*Oestrus ovis*
Rao S. (2018) [71].	India	M	38		Dust entered the eye	Foreign body sensation, watery eyes, eye redness, pain	Left	Congested conjunctiva, presence of mobile larvae, watery eyes	*Oestrus ovis*
Serra Moltó A. (2018) [105].	Spain	F	46		From Honduras	Pain, eyelid swelling (upper)	Right	Hyperemia of the upper eyelid, solution of continuity of the tarsal conjunctiva, and extruction of part of a worm.	*Dermatobia hominis*
Tabuenca-del Barrio L. (2018) [41].	Spain	F	39	Peasant	Get hit by a fly	Foreign body sensation	Right	Presence of mobile larvae	*Oestrus ovis*
	Spain	M	57	Farmer		Foreign body sensation	Right	Presence of mobile larvae	*Oestrus ovis*
	Spain	M	20		Get hit by a fly	Foreign body sensation	Right	Presence of mobile larvae	*Oestrus ovis*
	Spain	M	39	Farmer		Foreign body sensation	Right	Presence of mobile larvae in the conjunctival sac fundus.	*Oestrus ovis*
Couto Junior AS (2018) [149].	Brazil	M	44			Eyelid edema, irritation, discharge secretion	Right	Presence of mobile larvae, drainage hole in the upper palpebral angle	*Dermatobia hominis*
Armas-Herrera L. (2018) [150].	Peru	M	14		Lives in a rural area	Foreign body sensation, pruritus, eye redness, irritation	Left	Conjunctival hyperemia, presence of mobile larvae, chemosis	*Oestrus ovis*

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Ibáñez-Navarro A. (2018) [151].	Spain	M	56	Farmer		Foreign body sensation, pruritus	Right	Presence of mobile larvae	*No*
Fries FN. (2018) [152].	Germany	F	42	Tourist to Greece	Contact with sheep	Mobile foreign body sensation, pruritus	Left	Presence of a mobile larva	*Oestrus ovis*
Sudhir S. (2018) [153].	India	F	28	Student	Direct splash	Foreign body sensation, watery eyes, pruritus, pain	Left	Multiple larvae in the upper and lower cul-de-sacs	*Oestrus ovis*
	India	M	24	Student	Insect entered the eye	Watery eyes, pruritus, photophobia, irritation	Left	Multiple larvae in the upper and lower cul-de-sacs	*Oestrus ovis*
Gautam N. (2019) [65].	India	F	26	Peasant	Something entered the eye	Foreign body sensation, watery eyes, pain, irritation	Right	Congested conjunctiva, presence of mobile larvae in the palpebral and bulbar conjunctiva, watery eyes	*Oestrus ovis*
Jordan V (2019) [47]	Jamaica	M	17	Farmer	Foreign body sensation	Foreign body sensation, pruritus, eye redness, pain	Left	Conjunctival congestion, presence of three mobile larvae	*Oestrus ovis*
D'Assumpcao C. (2019) [91].	USA	M	16	Teenager	History of playing on a field fertilized with manure	Mobile foreign body sensation, eye redness, irritation	Left	Conjunctival hyperemia, presence of multiple larvae in bulbar conjunctiva and fornix.	*Oestrus ovis*
Dutta Majumder P. (2019) [72].	India	M	58			Eye redness, irritation	Right	Presence of mobile larvae, hyperemia of the bulbar and palpebral conjunctiva	*Oestrus ovis*
Mamani-Quispe P. (2019) [92].	Peru	M	26	Chef		Foreign body sensation, watery eyes, eye redness	Left	Presence of mobile larvae, Mild bulbar conjunctival hyperemia	*Oestrus ovis*

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Can FK. (2020) [81].	Turkey	F	55	Cattleman		Pruritus, eye redness, burning pain	Right	Conjunctival hyperemia, eyelids edema	*No*
Gupta AK. (2020) [12].	India	M	52	Hairdresser	Something entered the eye	Foreign body sensation, eye redness	Left	Conjunctival congestion, chemosis, watery eyes, palpebral edema	*Oestrus ovis*
Hartmannová L. (2020) [43].	Czech Republic	M		Tourist in Greece	Sawdust entered the eye	Watery eyes, pain	Left	Presence of larvae, minor erosion of the corneal epithelium, hyper-perfusion of the conjunctiva	*Oestrus ovis*
Farias LABG. (2020) [7].	Brazil	M	51	Alcoholic	Trauma	Pain, erythema, sensation of worms moving in the eyelid	Eyelid (left lower)	An ulcerated lesion with erythematous margins containing numerous larvae	*Cochliomyia macellaria*
Dadaci Z. (2020) [83].	Turkey	M	47		Attack of a fly while in the garden	Mobile foreign body sensation, pruritus, eye redness	Right	Conjunctival hyperemia, presence of larvae, eyelid edema (upper)	*Oestrus ovis*
Sen P. (2020) [68]	India	M	1		Cohabitation with domestic animals	Eye redness, edema, ocular discharge, bleeding	Eyelid (right upper and lower)	Conjunctival congestion, presence of mobile larvae, chemosis, periorbital eyelids edema and hyperemia, hyperemic, tender, and edematous skin in the adjacent facial area.	*Oestrus ovis*
Balamurugan R. (2020) [69].	India	F	26	Farmer	Foreign body entered the eye	Watery eyes, eye redness, mucopurulent discharge	Left	Presence of larvae	*Oestrus ovis*
Pupić-Bakrač A. (2020) [99].	Republic of Croatia	M	30	Pastor	Get hit by a fly	Foreign body sensation,	Right	Conjunctivitis (severe), presence of	*Oestrus ovis*

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						eye redness, irritation		mobile larvae, chemosis	
	Republic of Croatia	F	76	Pastor	Get hit by a fly	Eye redness, irritation	Right	Congested conjunctiva, presence of a mobile larva, eyelid edema	*Oestrus ovis*
Kunduracı MS (2020) [154].	Turkey	F	18			Foreign body sensation, watery eyes, eye redness	Left	Multiple mobile larvae, edema and hyperemia of the left eyelid, chemosis,	*Oestrus ovis*
Jiang Y. (2020) [132].	USA	M	44	Homeless person	Multiple predisposing factors	Pain, headache, blurred vision	Right	Presence of a mobile larva, chemosis, conjunctivitis, central corneal epithelial defect	*No*
Maharjan N (2021) [155].	Nepal	M	22			Foreign body sensation, watery eyes, eye redness, photophobia	Left	Congestive conjunctiva, numerous larvae, watery eyes, eyelid edema	*Oestrus ovis*
	Nepal	F	38		Insect bite in the eye	Foreign body sensation, redness, eyelid edema	Right	Congestive conjunctiva, numerous larvae, watery eyes, eyelid edema	*Oestrus ovis*
Singh A. (2022) [62].	India	M	45		Foreign body sensation	Mobile foreign body sensation, irritation	Right	Conjunctival congestion, presence of larvae, watery discharge	*Oestrus ovis*
	India	M	32		Foreign body sensation	Foreign body sensation, watery eyes, pain	Right	Conjunctival congestion, presence of larvae, watery discharge	*Oestrus ovis*
	India	M	28		Something strikes the eye	Foreign body sensation, watery eyes, pain	Left	Conjunctival congestion, presence of larvae, watery discharge	*Oestrus ovis*
Abihaidar N (2022) [156].	France	M	53		Lived near a horse and sheep farm	Foreign body sensation	Right	Conjunctival hyperemia, presence of mobile larvae	*Oestrus ovis*

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Naujokaitis T. (2022) [157].	Germany	F	42		Contact with flies	Foreign body sensation, eye redness, burning eye	Right	Presence of mobile larvae, conjunctival injection, scanty secretion	*Oestrus ovis*
Tamponi C (2022) [93].	Italy	F	30	Tourist	Foreign body entered the eye	Watery eyes, presence of larvae		Conjunctival hyperemia, presence of mobile larvae, blepharospasm	*Oestrus ovis*
	Italy	F	32	Tourist		Mobile foreign body sensation, watery eyes, pruritus, eye redness		Hyperemic conjunctiva, numerous larvae, palpebral edema	*Oestrus ovis*
	Italy	F	17	Tourist	Direct splash	Foreign body sensation, eye burning	Left	Presence of a mobile larva, moderate conjunctival hyperemia	*Oestrus ovis*

4.3. Diagnosis

A high index of suspicion is necessary for both the ophthalmologist and the entomologist to make a correct diagnosis [27]. The symptoms of external ophthalmomyiasis are nonspecific. Therefore, it can be misdiagnosed as any other type of acute viral or bacterial conjunctivitis if myiasis is not considered by clinicians [28]. In the case of *Oestrus ovis* ophthalmomyiasis, the manifestations of human conjunctival myiasis are usually short-lived and self-limiting, as the larvae cannot develop further and die within 10 days [28].

In the vast majority of cases, ophthalmomyiasis diagnosis is made via slit-lamp biomicroscopy, but in remote endemic regions, the dermatoscope has been successfully used as a portable tool for the diagnosis of ophthalmomyiasis externa [29,30].

During slit-lamp examination, *Oestrus ovis* shows negative phototaxis, with the small, translucent larvae moving away from the light quite quickly. This could lead to misdiagnosis if the larvae are missed, as it is possible for them to hide in the fornix of the patients eye. Morphological properties of *Oestrus ovis* larvae are relatively typical but differ in some cases, so molecular verification of the evidence is recommended [31]. However, this is not routine procedure.

In most cases covered in previous studies, exact taxonomic classification of the extracted larvae is performed, providing an idea of the potential risk of intraocular complications. In addition, in previous studies, larvae were preserved in 70% alcohol and sent to a specialist, who performed the identification and taxonomic classification [32].

Differential diagnoses include follicular conjunctivitis, foreign body conjunctivitis, catarrhal conjunctivitis, and other infestations, such as those of tiny *Paederus spp*. beetle, which sometimes penetrates the conjunctival border. The significant criteria for the diagnosis of ophthalmomyiasis are as follows: the sudden sensation of a foreign body causing sudden itching and tearing occurring while the patient is in an endemic area during warmer months, with the subject not necessarily noticing any flies [33].

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4.4. Treatment

The treatment for ophthalmomyiasis involves removing the larvae with tweezers, followed by anti-inflammatory drugs and local antibiotics [34]. This method provides immediate relief for patients without adverse effects on their vision. For *Oestrus ovis* infestations, manual extraction and local antibiotic application were used in 109 cases (52.8%), while manual extraction, antibiotic application, and local steroid use were employed in 86 (41.3%). For *Dermatobia hominis* infestations, surgical removal was performed in 10 cases (58.8%), and surgical removal with antibiotic administration was carried out in 4 cases (23.5%). *Lucilia sericata* infestation was treated with manual removal and antibiotic application in two cases and with steroid application in only one case. In cases of external ophthalmomyiasis caused by *Chrysomyia bezziana*, manual larva extraction and local antibiotic application were used in two cases. Manual extraction with systemic application of antibiotics and ivermectin was reported in only one case (Table 3).

Table 3. Treatment used in cases of external ophthalmomyiasis from 2000 to 2022.

Oestrus ovis	**%**	***Dermatobia hominis***	**%**	***Lucilia sericata***	**%**	***Chrysomya bezziana***	**%**
Manual extraction	2.9	Surgical removal	58.8	Extraction + antibiotic	66.7	Extraction + antibiotic	66.7
Extraction + ivermectin systemic	0.5	Surgical removal + antibiotic	23.5	Extraction + antibiotic + steroid	33.3	Extraction + antibiotic + ivermectin	33.3
Extraction + ivermectin + antibiotic	0.5	Surgical removal + ivermectin	11.8				
Extraction + local antibiotic	52.8	Surgical removal + antibiotic + steroid	5.9				
Extraction + antibiotic + local steroid	41.3						
Local antibiotic + analgesic + extraction	1.9						
Extraction + tobacco infusion	0.5						

4.5. Complications

External ophthalmomyiasis caused by *Oestrus ovis* is generally associated with a low incidence of complications, such as subconjunctival hemorrhage or blindness [15,35]. Nonetheless, a few rare cases of severe complications have been documented, including diffuse stromal keratitis and anterior uveitis [36]. In Korea, 18 cases of *Oestrus ovis* infestation were reported [37], with corneal infiltration occurring in 3. Although infestation generally starts with first-instar larvae, third-instar larvae have been discovered in patients with severe illnesses such as cancer or immunodeficiency [38].

5. Discussion

External ophthalmomyiasis caused by *Diptera* insect larvae in the conjunctival sac is the most common form of ophthalmomyiasis. Our review (including 117 publications reporting 312 cases) shows that it is prevalent in regions where sheep or goats are raised, including India, Jordan, Turkey, Iran, Libya, Tunisia, Spain, and Italy [1,14,34,37,39-42]. In the past decade, there have been reported cases of this infection in countries where autochthonous cases were previously unknown, such as the

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Czech Republic, Bulgaria, Australia, China, Serbia, South Africa, Jamaica, Morocco, Japan, Indonesia, Canada, Barbados, Belgium, Iraq, United Kingdom, Honduras, and Bolivia [17,43-58]. Despite its global prevalence [6,14], most reported cases are still concentrated in India, Turkey, Iran, and Libya [35,24,59,60].

India has experienced a substantial number of external ophthalmomyiasis cases over the last two decades, as evidenced by nine case series studies, with Misra S. et al. conducting the largest study in 2008, including 13 cases [34]. Other studies by Singh P.K. et al. in 2012, Sucilathangam G. et al., and Choudhary P. et al. in 2013 reported 3, 10, and 7 cases, respectively [25,35,61]. Singh et al. reported three cases in 2002 [62], while in the other 22 reports, one or two cases were reported [2,12,27,28,63-76]. The causative agents identified in India were *Oestrus ovis*, *Musca* ssp., *Musca domestica*, and *Chysomyia bezziana*. Given the socioeconomic conditions and climate change, it is imperative to address ophthalmomyiasis as a potential health concern in India.

According to Thabit A.M. et al. [77], 49 cases of external ophthalmomyiasis were found in Jordan, but the causes were not determined. It was observed that most of the affected individuals were male, with an average age of 31.6 years, which is consistent with the previous research comprising 312 cases. Alameri O.H. et al. [39] reported only one case caused by *Oestrus ovis* in 2014. However, the actual number of cases may be higher than reported due to underreporting and the mild symptoms experienced in most cases.

Turkey has been experiencing a surge in cases of external ophthalmomyiasis over the past 22 years, which cannot be attributed to known risk factors. Turkey ranks third in the world in the number of reported cases. Various studies have reported case numbers ranging from one to twelve [24,26,40,78-88], with the causative agent predominantly being *Oestrus ovis* and *Chrysomyia bezziana* in only one case [85]. Interestingly, cases have occurred more frequently in urban areas without known animal contact.

5.1. Risk factors

External ophthalmomyiasis cases have been reported across Asia, Europe, and South America from 2000 to 2022, with a high incidence in countries such as India, Jordan, Turkey, Iran, and Brazil. As shown in Table 1, the geographical distribution of the flies responsible for this disease is mainly in warm and humid tropical or subtropical areas ideal for fly breeding [6]. External ophthalmomyiasis is more prevalent in pastoral or rural areas than urban centers, especially in developing countries with inadequate basic sanitation and garbage disposal [34,40,77]. Nevertheless, due to the rise of international travel, infection can also occur in non-endemic areas [43,46,50]. Since larvae enter the eye outdoors, men are more likely to be affected than women, as demonstrated in our review, with a higher proportion of cases occurring in males (with a 2:1 male-to-female ratio) [62].

Unfortunately, occupations such as farming, shepherding, and veterinary work come with inherent risks. Studies conducted in India have revealed that approximately 51.75% of individuals with these jobs are at an increased risk of infestation [34,35,61]. Research by Hira et al. [89] and Masoodi et al. [90] found a higher incidence of ophthalmomyiasis in areas where sheep and goats are raised, indicating that myiasis is an occupational disease for farmers and shepherds. However, in this review, only 32.17% of cases were associated with occupational activities. Ophthalmomyiasis is common in urban areas, affecting teachers, office workers, nurses, and students [33,91,92].

It is important to note that tourist and recreational activities accounted for 10.49% of all reported cases. Tamponi C. et al. [93] documented three instances of external ophthalmomyiasis in Italian tourists, while Cucera A. et al. [94] reported two cases in German tourists. Dorchies [95] noted that external ophthalmomyiasis is usually accidental.

Various factors can heighten the likelihood of developing ophthalmomyiasis [74,96,97]. These include eye infections or injuries (whether from surgery or trauma), advanced age, persistent illnesses such as infections or cancer, HIV infection, alcoholism, diabetes, psychiatric disorders, poor overall health, homelessness, and close contact with farm animals.

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The use of manure as fertilizer in urban areas [91] is a controllable risk factor for external ophthalmomyiasis. Reducing the use of manure in gardens or recreational areas frequented by people is highly recommended to prevent the spread of infections. This is particularly critical when the manure is obtained from grazing fields with *Oestrus ovis* host animals [98]. Livestock grazing pens may be the only source of infection in areas without livestock.

5.2. Etiological agent

In 2020, Pupić-Bakrač A. et al. [99] documented two cases of external ophthalmomyiasis caused by *Oestrus ovis* in an urban area of Croatia. Another of their studies revealed 260 cases of human ophthalmomyiasis, with 259 (99.62%) cases of external ophthalmomyiasis (*Oestrus ovis*) and only 1 case of internal ophthalmomyiasis (0.38%). Similarly, Akbarzadeh K. et al. [100] and Abdellatif M.Z. et al. [14] also identified *Oestrus ovis* as the cause. Our review of cases across a wide geographical distribution [25] (Asia, Europe, Africa, Australia, and America) published in the last 22 years found that 225/352 (72.12%) cases had external ophthalmomyiasis (*Oestrus ovis*), with 18% of cases not reporting the causative agent [25]. This differs from studies that identified *Oestrus ovis* as the cause in endemic Mediterranean countries [14,99,100], including cases reported since the 1970s. Most patients engaged in agricultural activities (such as sheep/goat breeders, ranchers, farmers, and peasants) are prone to ophthalmomyiasis (*Oestrus ovis*), as reported by Pupić-Bakrač A. [99], Thakur K. [2], and Abdellatif M.Z. [14]. However, our findings contrast theirs, as only 38.4% of cases of external ophthalmomyiasis were associated with risky work activities. It is worth noting that more cases of ophthalmomyiasis have been reported that were not linked to risky work activities, which is likely due to the impact of global warming creating a more suitable habitat for the survival of *Oestrus ovis* and not to increased reporting [35,101-103].

Ophthalmomyiasis cases reported in Turkey [60] and Iran [100,104] were primarily caused by *Oestrus ovis*, with additional cases attributed to various diptera such as *Sarcopha* sp., *Rhinoestrus purpureus, Hypoderma bovis*, and *Chrysomyia bezziana*. Similar cases have been reported in Middle Eastern and Mediterranean countries over the past 22 years. *Oestrus ovis* is the most common cause, but occasionally, other diptera of different genera, such as *Chrysomyia bezziana* or *Sarcopha* sp., are the cause. It is crucial to address this issue promptly to prevent further spread and harm.

External ophthalmomyiasis cases in the Americas are usually caused by fly larvae from South America (*Dermatobia hominis*) or Africa (*Cordylobia anthropophaga*) and typically occur in tourists returning from endemic regions [52,104,105]. However, diagnosing North American patients without a recent travel history can be challenging [106]. *Cuterebra* species are the most common cause of myiasis in North American patients who have not traveled to endemic regions [107]. These large bee-like flies are native to the northeastern United States and southeastern Canada [106].

5.3. Clinical manifestations

Clinicians must consider ophthalmomyiasis a possibility in patients exhibiting non-specific symptoms, as demonstrated in this study and various others [24]. Failure to do so in endemic areas or tourists returning from such regions may lead to mistaking ophthalmomyiasis for other forms of conjunctivitis [28]. Symptoms typically resemble acute catarrhal conjunctivitis and include burning, stinging, itching, increased tearing, and the sensation of a foreign object in the eye [6].

Regarding ophthalmomyiasis caused by *Oestrus ovis*, patients commonly report foreign body sensations, red eyes, and excessive tearing, all of which indicate significant irritation in the affected eye [35,62,99]. These symptoms are consistent with the behavior and structure of the larvae, which are equipped with hooks and oral spines that can irritate as they move across the conjunctiva and cornea [62]. Meanwhile, cases of *Dermatobia hominis* commonly result in symptoms such as eyelid swelling, redness around the eye, and a feeling of movement in the lesion, which are consistent with other reports [13,108]. External ophthalmomyiasis induced by *Lucilia sericata* typically causes pain, foreign body sensation, itching, and excessive tearing, which is similar to the findings of another study [18]. Finally, *Chrysomyia bezziana* often results in symptoms such as the emergence of maggots

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from the wound, smelly discharge, swelling, and itching, which has been reported by other researchers [6,109].

Research findings support that external ophthalmomyiasis symptoms can manifest immediately or several hours after contact with the fly, depending on whether the fly's eggs or larvae are active. The onset of symptoms is directly related to the time it takes for the eggs to hatch. It is important to note that clinical signs appear immediately after contact with *Oestrus ovis*, while with *Musca domestica* or *Dermatobia hominis*, symptoms may appear a few hours later. These findings are supported by extensive research [4,6,62,110,111].

Oestrus ovis Infestations may cause brief and self-limiting ophthalmomyiasis symptoms, as the larvae cannot survive for more than ten days [75]. However, invasive manifestations may occur in rare cases depending on host factors [99,112]. Internal ophthalmomyiasis has been reported [113], but it is uncommon. External ophthalmomyiasis usually affects only one eye, but there have been more frequent cases of bilateral involvement [2,48] in recent years, with ten reported cases [10,15,25,26,34,73,114,115] over the past 22 years. *Oestrus ovis*, *Sarcophaga argyrostoma, Musca domestica*, and one unreported species were responsible for the infestations, demonstrating that bilateral involvement is still uncommon but not rare.

Over 22 years, numerous cases reports strongly indicate the possibility of experiencing a foreign object sensation in the eye after being struck by a fly [2]. It is essential to accurately differentiate this particular sensation from other conditions that may present similar symptoms [2]. In humans, the larvae are usually found in the outer part of the eye, causing discomfort and irritation [2]. The larvae use their mouth hooks to attach to the eye, contributing to this discomfort [2].

External ophthalmomyiasis is characterized by severe local conjunctival inflammation that can cause uncomfortable symptoms such as foreign body sensation, irritation, redness, photophobia, lacrimation, and decreased visual acuity. Signs of this condition include erythema, periorbital edema, conjunctival edema, hemorrhages, chemosis, and superficial punctate keratitis. Additionally, some patients may experience a sensation of movement within the eye [2,48]. In some cases, the eyelids may also be affected, leading to edema [105], which can be mistaken for a chalazion or preseptal cellulitis. However, identifying the respiratory pore and feeling contortion within the lesion can help diagnose cases caused by *Dermatobia hominis* [116]. It is imperative to promptly seek medical attention in case of experiencing any of these symptoms.

5.4. Diagnosis

With over 85,000 species in the *Diptera* order, only a select few are responsible for causing ophthalmomyiasis. Expert identification of the larvae causing external ophthalmomyiasis is based on the classification of their posterior spiracle and cephaloskeleton structure [117]. It is of utmost importance to identify the species of flies involved, as some can cause substantial harm to deeper eye tissues and affect vision [2]. While viral and bacterial infections are the most common causes of red eyes, parasitic infestations can also lead to unilateral red eyes [28]. Therefore, external ophthalmomyiasis should be considered a possible cause of pink eye, even in healthy individuals residing in large cities [83], as approximately 15% of cases reported over the last two decades have occurred in healthy people with no history and living in large cities [44,46,91].

External ophthalmomyiasis is a condition that can be diagnosed by observing larvae or worms in the conjunctiva and/or adnexa. It is essential to have a high index of suspicion to correctly diagnose the condition, as small numbers of larvae may be present, which can be mistaken for acute conjunctivitis [118]. Our findings are consistent with an average of seven larvae reported in patients from Libya [14] who had ophthalmomyiasis caused by *Oestrus ovis*. In cases caused by *Dermatobia hominis*, only one larva was reported in each, except in a 2-month-old infant with one larva in the left upper eyelid and two in the left lower eyelid [13]. For external ophthalmomyiasis caused by *Lucilia sericata* and *Chrysomyia bezziana*, the mean numbers of larvae reported were 12.3 [17,18] and 24.5 larvae [51,74,85], respectively.

5.5. Treatment

There is no specific treatment for ophthalmomyiasis. Nevertheless, in post-larval removal, it is advisable to provide anti-inflammatory drugs, antibiotics, and ivermectin, as they have been successfully employed in documented cases [44,74,76,119] for the past two decades.

External ophthalmomyiasis requires immediate removal of the larvae under local anesthesia and the application of antibiotics to prevent bacterial infection. Anesthetic drops can paralyze the maggots and facilitate their removal [120]. Even though patients may experience immediate relief, it is essential to have a follow-up examination within 24 to 48 hours to ensure that any remaining larvae in the conjunctival sac fundus are treated. If any larvae are left behind, the initial treatment may not be effective [1]. Despite the painful and alarming symptoms, external ophthalmomyiasis can be successfully cured [121].

Our review found that despite the high number of larvae in cases of external ophthalmomyiasis caused by *Oestrus ovis*, *Chrysomyia bezziana*, or *Lucilia sericata*, all reported cases were completely cured. Anane S. and Hssine L.B. [1] reported 11 cases of complete cures in 2020, highlighting the importance of prompt treatment and complete removal of the larvae to prevent complications. Therefore, seeking early treatment for external ophthalmomyiasis cases is imperative to prevent further complications.

Based on the evidence reviewed, the initial treatment step is recommended to consist of larvae being immediately immobilized with local anesthetic eye drops and extracted. The second step is to apply antibiotics and topical anti-inflammatories to alleviate symptoms and prevent secondary infection. This recommended treatment sequence aligns with previous publications by Thakur et al. [2] and Abdellatif M.Z. [14]. To avoid potential complications or recurrence, it is recommended to schedule a follow-up examination [1].

To effectively treat a *Dermatobia hominis* infestation, immediate surgical removal of the larvae is strongly recommended to minimize inflammation and the possibility of requiring more extensive surgery. It is essential to thoroughly examine patients for additional skin infestations [13,52,105,106]. Symptoms subside once the larvae are removed, and a favorable prognosis is expected [116].

5.6. Travelers

Myiasis is a common dermatologic disease among travelers, and ophthalmomyiasis accounts for 5% of all cases of myiasis [93,94]. External ophthalmomyiasis related to tourism accounts for 8.9% of cases. Therefore, if a tourist returns from an endemic area such as India, Jordan, Libya, Turkey, Iran, Tunisia, Spain, Italy, or French Guiana with symptoms such as red eye, unilateral conjunctivitis, or foreign body sensation [1,43,45,52,54], physicians should consider external ophthalmomyiasis as a possible cause and conduct a thorough examination [56]. Physicians in non-endemic regions unfamiliar with this infestation may find this challenging, especially when other organs besides the skin are affected [6]. Therefore, it is crucial to remain vigilant and not overlook this possibility.

5.7. Military deployments

With the increasing frequency and duration of military deployments worldwide, civilian and military medical professionals must know the potential hazards of exposure to various conditions. Some conditions, such as ophthalmomyiasis, may not be commonly diagnosed by medical personnel [55,122]. To prevent insect-borne disease transmission, personnel deployed to war zones and areas with insect vectors should equip themselves with protective eyewear [123].

5.8. Global warming

In the last two decades, an increased prevalence of oestrosis in humans and sheep has been observed in endemic areas, as well as a broader geographic expansion into areas not previously considered endemic. However, the appearance of new cases is attributed to the effect of global warming creating a suitable habitat for the survival of *O. ovis* and not to the increase in notification

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as shown by Ahaduzzaman [124], Weaned F.S. [125], Basmaciyan et al. [102], Sucilathangam et al. [35], Zhang A. [46] and Taylor [103]

Cases linked to the effects of global warming have been reported in Germany and France, specifically concerning *Oestrus ovis* [125] and *Oestrus sp*. [102], causing external ophthalmomyiasis. Surprisingly, despite these regions' typically cold and wet climates, significant warming during spring and summer has allowed for the establishment of these flies. Furthermore, temperature changes between 1961 and 2011 in Burgundy [126], France, showed a more accelerated warming trend than the global average, leading to the implantation of *Diptera* of the genus *Oestrus sp*. during the vegetative season. This warming is more pronounced in diurnal temperatures and has impacted the establishment of these *Diptera* in regions previously considered cold and humid [127]. Another case associated with global warming is that a 30-year-old man in Shandong [46], China, experienced autochthonous external ophthalmomyiasis despite the city being cold and dry for most of the year. Therefore, global warming is significantly impacting the establishment and spread of Diptera, which is a cause for concern. Action must be taken to address this issue before it is too late.

Global warming has affected the behavior of *Oestrus ovis*, causing them to change their egg-laying habits. Due to the human facial structure, these flies confuse our pupils with cattle nostrils, leading to increased ophthalmomyiasis cases. It is worth noting that even individuals who have not had contact with animals or visited areas where the disease is prevalent have been affected. These occurrences have been documented in [42,122].

The attraction of *O. ovis* to humans is underestimated [128]. *Oestrus ovis* is an insect that infests urban areas due to the zooprophylaxis phenomenon. Humans become the primary target for these flies when there is a shortage of other hosts, thereby increasing the risk of infection [129]. Various weather conditions, such as air temperature, humidity, light intensity, altitude, latitude, and wind speed, influence this type of fly. Attacks usually occur when the air temperature is above 20 °C, with the highest frequency between 25 °C and 28 °C. The most frequent attacks occur at an air temperature of 26 °C and under calm to moderate wind conditions. Furthermore, the relative humidity range also affects the fly, with the highest peaks between 65% and 85%. Climate change has been identified as the main factor influencing the behavior of *Oestrus ovis* in several regions, increasing temperature and the fly's infestation rates [99,130]. In contrast, cases of *Dermatobia hominis* infestation are typically linked to travel or residency in Latin America, where the species is native [13,52,105,106,116]. However, due to global warming, this species may migrate to previously unsuitable areas for its survival [131] as areas in North America experience warmer temperatures.

5.9. Prevention

Ophthalmomyiasis is not a minor disease and poses a significant public health concern, especially in developing countries such as India, Jordan, and Turkey [27,34,39,76,77,85,87,88]. However, the larvae responsible for this disease are often discarded without proper examination [6], leading to inadequate case recording. Access to dipteran classification experts can be challenging in such regions. It is important for ophthalmologists to include ophthalmomyiasis in their differential diagnosis of conjunctivitis [86] and for physicians to remember that this condition can occur not only in tropical or subtropical areas but also in other non-endemic regions [80,84,125,132] with more temperate climates. Diagnosis of ophthalmomyiasis heavily relies on expertise [24]. Most external ophthalmomyiasis lesions occur in exposed areas, so using mosquito repellent [133] and nets for windows and ventilation ducts [17] can be the best preventive measures.

Preventing the spread of disease can be achieved by avoiding exposure to adult flies and using insecticide spray to kill them. Raising awareness is crucial in combatting this preventable endemic disease in rural areas [34,76,77,88]. Travelers must be informed of the necessary preventive measures based on their destination to avoid myiasis [45,52,54, 56,94]. It is advisable to avoid endemic countries where farm animals are left unattended to reduce the risk of contracting myiasis. If any symptoms of myiasis are experienced, consulting a physician is recommended. Additionally, physicians should consider ophthalmomyiasis as a possible cause of conjunctivitis in tourists visiting endemic areas or in individuals working with farm animals, such as farmers, ranchers, and veterinarians [86].

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5.10. Weaknesses

It is likely that more cases of ophthalmomyiasis are caused by *Oestrus ovis* than what is currently documented. Many cases lack crucial details, such as the time of diagnosis or the condition's cause. Underreporting is a leading factor in this issue, as patients with ophthalmomyiasis caused by *Oestrus ovis* often do not seek medical attention. Additionally, the larvae responsible for the condition die within the first ten days of infestation in humans, which could lead to misdiagnosis and further underestimation of cases.

6. Conclusions

It can be challenging to determine the exact number of individuals impacted by external ophthalmomyiasis because cases caused by *Oestrus ovis* usually have mild symptoms that are easily resolved by removing the larvae. As a result, patients typically recover completely and do not experience any lasting effects. This means that some cases may not be recorded or reported, leading to a lower estimated global number of affected individuals.

External ophthalmomyiasis is a commonly underestimated condition, especially in dry rural areas. It is often misdiagnosed as viral, bacterial, or allergic conjunctivitis, which can be detrimental to the patient's health. Therefore, physicians must be aware of its prevalence and symptoms. Early recognition and a greater medical understanding are necessary to prevent the development of internal ophthalmomyiasis, a severe condition that can significantly affect the patient's visual prognosis.

Individuals residing in regions with high fly larvae infestation rates are at significant risk of contracting ocular infections. Physicians must consider the possibility of ophthalmomyiasis when diagnosing anterior segment inflammation. Travelers must know that ophthalmomyiasis can be averted by taking appropriate preventive measures based on their destination. Medical professionals must also caution travelers visiting endemic regions about the risk of myiasis if they fail to undertake preventive measures.

Moreover, it is crucial to identify autochthonous cases of external ophthalmomyiasis in non-endemic areas to evaluate the impact of climate change on establishing Diptera, specifically the Oestrus genus.

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