The Journal of Medical Entomology and Parasitology is one of the series issued quarterly by the Egyptian Academic Journal of Biological Sciences. It is an important specialist journal covering the latest advances in that subject.

It publishes original research and review papers on all aspects of basic and applied medical entomology, parasitology and host-parasite relationships, including the latest discoveries in parasite biochemistry, molecular biology, genetics, ecology and epidemiology in the content of the biological, medical entomology and veterinary sciences.

In addition to that, the journal promotes research on the impact of living organisms on their environment with emphasis on subjects such as resource, depletion, pollution, biodiversity, ecosystem…..etc.

www.eajbs.eg.net
A Brief Review of Myiasis with Special Notes on the Blow Flies’ Producing Myiasis (F.: Calliphoridae)

Eslam M. Hosni*, Mohamed A. Kenawy; Mohamed G. Nasser, Sara A. Al-Ashaal and Magda H. Rady

Department of Entomology, Faculty of Science, Ain Shams University, Abbassia, Cairo 11566, Egypt
E-mail: iobek@sci.asu.edu.eg

ARTICLE INFO

Article History
Received:26/8/2019
Accepted:25/9/2019

Keywords:
Myiasis, Flies, Calliphoridae, Diptera.

ABSTRACT

One of the most interesting and sophisticated relations that are seen in nature is myiasis which represents the relation between these tiny small larvae of Diptera and another living creature where these larvae feed on its tissues. Several previous works discussed the issue of myiasis from different aspects. In this work, a brief and comprehensive review of myiasis including classification of its types, classification of dipterous larvae that cause it and special notes on family Calliphoridae and its role in causing myiasis.

INTRODUCTION

In nature, the relationships among living organisms are very complicated. Significant observations and continuous surveillance allow us to understand this complexity. One of these relations is the association between flies and targeted vertebrate hosts. Although the apparent difficulty, the association could simply be either detrimental or beneficial (Hall and Wall, 1995).

Earlier in 1815, Kirby and Spence were the first to use the term “scholechiasis” to describe the animal diseases caused by insect larvae. Then in 1840, Hope conceived a new term “Myiasis” which defines the invasion of human and animal bodies with dipterous larvae and referred the terms “scholechiasis” and “canthariasis” to the disease caused by larvae of Lepidoptera and Coleoptera, respectively (Hall and Wall, 1995). Later, De la Torre-Bueno (1937) indicated, in Glossary of Entomology, that myiasis is "The disease or injury caused by the attack of dipterous larvae". Zumpt (1965), gave the practical and accurate definition of term myiasis as "The infestation of live human and vertebrate animals with dipterous larvae, which, at least/or for a certain period, feed on the host’s dead or living tissue, liquid body-substances, or ingested food”.

Myiasis is considered a neglected disease with great economic impacts on animals and humans (Hall et al., 2016). From ancient times till recent days myiasis causing flies occupied Holarctic and Holotropic regions. The power of this widespread is referred to a wide variety of hosts from wild and domestic animals and even humans (Francesconia and Lupi, 2012). Myiasis is widespread throughout the world especially the tropical regions. It usually occurs in both domestic and wild animals and incidentally in humans under certain conditions (Hall and Wall, 1995 and Hassona et al., 2014).
In animals, the odor of infected wounds, decayed organic matters, urine, and feces attract gravid fly females to lay their eggs. Then the voracious larvae consume necrotic tissues and pervade healthy ones producing deep injury (Zumpt, 1965). In humans, although the infestation is rare; about 165 cases of human myiasis were reported from 1914 till 2014 (Sing and Sing, 2015). The predisposing factors like low socioeconomic status, poor hygiene, mental regardless patients without care and drug addicts increase the disease incidence. Moreover, the pathogenicity of myiasis is asymptomatic and may lead to death due to septicemia and toxemia (Singh and Singh, 2015).

This review is objected at providing information related to the types of myiasis and its causing flies. Due to the economic and health impacts of this injury to both animals and humans, efforts have to be intensified toward control of such fly pests.

**MATERIALS AND METHODS**

A review of the available published and unpublished reports on myiasis and flies producing such condition was performed on PubMed and Research Gate documents and internet-based articles. In addition, several related web pages were accessed. A total of 28 articles were included in this review.

**RESULTS AND DISCUSSION**

**Classification of Myiasis:**

Two main ways for myiasis classification: (1) The **Anatomical way** (Table 1) which is based on infested parts of the host's body. It was first proposed by bishop in 1922 and modified by James in 1947 then by Zumpt in 1965 (Gour et al., 2017) and (2) The **Ecological (Biological or Parasitological)** way (Table 2) according to the host-parasite relationship or level of dependence between dipterous larvae and hosts (Zumpt, 1965 and Hall and Wall, 1995). The former classification gives a short cut to identify the accused fly species, but the later one portrays the biology of the fly and permits understanding the evolution of myiasis habit (Hall and Wall, 1995).

**Table 1: Anatomical classification of Myiasis; after Hall and wall (1995)**

<table>
<thead>
<tr>
<th>Bishopp 1922</th>
<th>James 1947</th>
<th>Zumpt 1965</th>
</tr>
</thead>
<tbody>
<tr>
<td>01. Bloodsucking</td>
<td>01. Bloodsucking</td>
<td>01. Sanguinivorous</td>
</tr>
<tr>
<td>02. Tissue-destroying</td>
<td>02. Furuncular</td>
<td>02. Dermal/subdermal</td>
</tr>
<tr>
<td>03. Subdermal migratory</td>
<td>03. Creeping</td>
<td></td>
</tr>
<tr>
<td>04. An infestation of the head passages</td>
<td>04. Traumatic/wound</td>
<td></td>
</tr>
<tr>
<td></td>
<td>05. Anal/vaginal</td>
<td></td>
</tr>
<tr>
<td></td>
<td>06. Nose, mouth, sinuses</td>
<td>03. Nasopharyngeal</td>
</tr>
<tr>
<td></td>
<td>07. Aural</td>
<td></td>
</tr>
<tr>
<td></td>
<td>08. Ocular</td>
<td></td>
</tr>
<tr>
<td>05. Intestinal/urogenital</td>
<td>09. Enteric</td>
<td>04. Intestinal</td>
</tr>
<tr>
<td></td>
<td>10. Anal/vaginal</td>
<td></td>
</tr>
<tr>
<td></td>
<td>11. Bladder, urinary passages</td>
<td></td>
</tr>
<tr>
<td></td>
<td>12. Anal/vaginal</td>
<td>05. Urogenital</td>
</tr>
</tbody>
</table>
A Brief Review of Myiasis with Special Notes on the Blow Flies’ Producing Myiasis

Table 2: Biological (Parasitological or Ecological) classification of myiasis, after Hall and Wall (2016)

<table>
<thead>
<tr>
<th>Classification</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obligatory (Specific)</td>
<td>Parasitic maggots depend on the live host for a time to complete their life cycle.</td>
</tr>
<tr>
<td>Facultative (Semi-specific)</td>
<td>Parasitic larvae develop on either living or decayed organic matters under three levels.</td>
</tr>
<tr>
<td>01. Primary</td>
<td>The larvae are free-living and able to initiate myiasis.</td>
</tr>
<tr>
<td>02. Secondary</td>
<td>The Larvae are unable to initiate myiasis and parasitize as a secondary species.</td>
</tr>
<tr>
<td>03. Tertiary</td>
<td>The larvae which parasitize the host near its death.</td>
</tr>
<tr>
<td>Pseudo-myiasis (Accidental or false myiasis)</td>
<td>The free-living nonparasitic larvae are accidentally affecting the host.</td>
</tr>
</tbody>
</table>

Biological (Ecological or Parasitological) Classification of Myiasis:

The causing flies are classified into three categories:

01. The **obligatory or specific myiasis producers** which develop only on live hosts (Zumpt, 1965 and Hall and Wall, 1995). Such flies select various host organs or tissues in which they deposit eggs or larvae. Examples of such flies are *Wöhlfartia magnifica* and *W. vigil* (Flesh flies), *Oestrus ovis* (Sheep bot fly), *Hypoderma bovis* (Warble fly), *Gasterophilus intestinalis* (Horse bot fly), *Cochliomyia hominivorax* (New-world screwworm) and *Chrysomya bezziana* (Old-world screw-worm) and *Dermatobia hominis* (Human bot fly or the Torsalo) (Kenawy, 2008).

02. The **facultative or semi-specific myiasis producers** (opportunistic) which develop on both living and decayed organic matters under three levels: primary wherein the larvae are able to initiate myiasis or secondary and tertiary when the host becomes near the death (James, 1947). Flies attack filthy infected wounds, stimulated by the odor and do not attack clean wounds or intact skin. Examples of these flies are *Calliphora* spp. (Bluebottle flies) and *Lucilia* spp. (Greenbottle flies), *Sarcophaga* spp. (Flesh flies), *Piophila casei* (Cheese skipper) and *Tubifera tenax* (Rat-tailed maggot) (Kenawy, 2008).

03. The **pseudo- or accidental myiasis producers** are those free-living nonparasitic larvae that are accidentally swallowed (Zumpt, 1965). Flies of family Muscidae are common in causing such false myiasis (Nagakura et al., 1991).

Anatomical Classification of Myiasis:

01. **Sanguinivorous Myiasis**: This term concerning dipterous larvae with voracious behavior towards blood. They are ectoparasitic and able to initiate obligatory myiasis. *Chrysomya bezziana* and *Auchmeromyia luteola* (Congo floor maggot) (Calliphoridae) and *Dermatobia hominis* (Oestridae) are sanguinivorous fly larvae (Zumpt, 1965).

02. **Cutaneous (Wound, Traumatic, Dermal or Sub-dermal) Myiasis**: is the most frequent type of myiasis (Visciarelli et al., 2007). In this condition, obligatory myiasis dipterous larvae feed on animal tissue (epidermis and dermis layers) causing wounds. These wounds or trauma, either caused by insects or others, attract other obligatory or facultative parasites to cause myiasis (Zumpt, 1965). Flies of families Calliphoridae and Sarcophagidae like...
Cochliomyia hominivorax, Lucilia sericata, and Wohlfahrtia magnifica could produce dermal and wound myiasis (Gour et al., 2017).

03. **Furuncular (Warble) Myiasis**: is considered a type of cutaneous myiasis and occurs after penetration of the healthy skin by dipterous larvae causing furuncular lesion or nodes. The furuncular lesion is a nodule with a central pore that exudates a purulent fluid after larval infestation. The number of maggots in the furuncular nodes varies according to fly species (Francesconia and Lupi, 2012). The number of lesions and their distribution patterns are fly species-dependent. *Cordylobia anthropophaga, Dermatobia hominis, Wohlfahrtia vigil, Wohlfahrtia magnifica,* and *Cuterebra* spp. are common agents of furuncular myiasis (Robbins and Khachemoune, 2010).

04. **Migratory (Creeping) Myiasis**: occurs when the maggots start to migrate for a distant in the host skin and burrow in it causing obvious migratory lesions. This migration produces ulcerated epithelium and causes inflammation in dermis layer. The larvae then diagnosed in the fibrous cystic sinus tract in dermis layer (Gour et al., 2017). *Hypoderma bovis* (Cattle bot fly) and *Gasterophilus intestinalis* (Horse bot fly) are common agents of migratory or creeping myiasis. Unintentionally, humans could be infested by cattle and horse bot flies but, the larvae are unable to complete their life cycle in human skin (Royce et al., 1999).

05. **Cavity Myiasis**: is an infestation of body cavities by dipterous larvae. This type usually receives its name from the anatomical region affected (Francesconia and Lupi, 2012).

06. **Ocular (Ophthalmic) Myiasis**: occurs due to the infestation of host eyes by dipterous larvae. Eye infestation could be internal, external or in the orbital part. Ophthalmomyiasis interna occurs when the infestation including the anterior and posterior segment of the eyeball (Jakobs et al., 1997). In Ophthalmomyiasis externa, the infestation is restricted to superficial ocular tissues. Red eyes, eye pain, and vision loss are described as symptoms of Ocular myiasis (Anane and Hssine, 2010). *Chrysomya bezziana, Dermatobia hominis, Lucilia* spp. and *Cuterebra* spp. are the common agents of ocular myiasis (Francesconia and Lupi, 2012).

07. **Oral Myiasis**: was first described by Laurence (1909). The incidence of oral myiasis is associated with poor oral hygiene, alcoholism, mental disability and other clinical forms like oral trauma and gingival diseases (Hassona et al., 2014). Also, people whose mouth remains open for a long time are susceptible to Oral myiasis (Sharma et al., 2008). Swelling of mouth, lips and gingival was reported as symptoms of Oral myiasis. The reported species are *Chrysomya bezziana, Cochliomyia hominivorax, Musca domestica, Wohlfahrtia magnifica* and *Calliphora vicina* (Hassona et al., 2014).

08. **Aural (Otom) Myiasis**: includes the infestation of the ear by dipterous larvae. Female flies oviposit eggs or larvae around the aural cavity (Uzun et al., 2004). Symptoms vary from itching, inflammation of auditory canal, aural pain to otorrhea and bleeding. The most common species that cause aural myiasis are *Chrysomya bezziana, Chrysomya megacephala, Cochliomyia*
**A Brief Review of Myiasis with Special Notes on the Blow Flies’ Producing Myiasis**

9. **Nasal Myiasis**: occurs when female flies deposit their larvae in the nasal cavity while the host is sleeping. In a study about 252 peoples older than 50 yrs. were suffering from nasal myiasis (Francesconia and Lupi, 2012). Low socioeconomic status and poor hygiene are predisposing factors of larval invasion (Francesconia and Lupi, 2012). Nasal pain, movement sensation, anosmia, nasal discharge, and nasal bleeding are common signs of nasal myiasis (Tsang and Lee, 2009). *Chrysomya bezziana*, *Cochliomyia hominivorax*, *Oestrus ovis*, *Lucilia sericata*, *Wohlfahrtia magnifica*, and *Drosophila melanogaster* and *Cephalopina titillator* (Camel bot fly) are the main agents of nasal myiasis (Francesconia and Lupi, 2012).

10. **Intestinal (Enteric) Myiasis**: is widespread in animals rather than humans where the alimentary tract of the mammals from pharynx to anus harbors larvae. Symptoms vary from asymptomatic cases to nausea, vomiting, abdominal pain and rectal bleeding (Karabiber et al., 2010). *Gasterophilus intestinalis* is the common maggot causing enteric myiasis (Singh and Singh, 2015). *Sarcophagidae* and *Calliphoridae* are the major families of Diptera (Tru flies) which causes myiasis (Hall and Wall, 1995). About 80 species of *Sarcophagidae* and *Calliphoridae* have been recorded to cause myiasis (Hall and Wall, 1995).

11. **Urinary Genital Myiasis**: is the infestation of urinary genital area of the host by dipterous larvae. The most common symptoms are lumbar pain, ureteric obstruction, and dysuria. The causing flies are *Wohlfahrtia magnifica*, *Sarcophaga haemorrhoidalis*, *Fannia canicularis*, and *Sarcophaga carnaria* (Francesconia and Lupi, 2012).

12. **Cerebral Myiasis**: is rare, fatal, and survival rates are low (Terterov et al., 2010). Species of *Hypoderma bovis* and *Hypoderma lineatum* were discriminated to cause cerebral myiasis (Francesconia and Lupi, 2012).

**Calliphoridae and Other Dipterous Families as Myiasis Producing Agents**

Order Diptera (Tru flies) currently includes more than 50,000 described species in 10,000 genera and about 150 families (Pape and Thompson, 2010). About thirteen families of this order compress all myiasis causing flies. These are *Calliphoridae*, *Oestridae*, *Sarcophagidae*, *Muscidae*, *Gastrrophilidae*, *Phoridae*, *Drosophilidae*, *Psychodidae*, *Stratiomyidae*, *Scenopinidae*, *Syripidae*, *Piophilidae* and *Dryomyzidae* (Singh and Singh, 2015) of which three families are the major ones: The first one is family *Oestridae* which contains 151 species in 28 genera. All species are obligate parasites in their larval stages. The second family is *Sarcophagidae* with 2000 species in 400 genera and the third family is *Calliphoridae* (Hall and Wall, 1995). About 80 species of *Sarcophagidae* and *Calliphoridae* have been recorded to cause myiasis (Hall and Wall, 1995).

*Calliphoridae* (blow flies, carrion flies, bluebottles, greenbottles, cluster flies) (Table 3) is one of the most common and interesting families of Diptera. It is classified into 6 subfamilies with 150 genera and about 1000 species. *Calliphoridae* flies are characterized by their metallic bodies with blue and green color, while some species are dull. The members of this family are performing several environmental services including, but not limited to decomposing of dead animal bodies and pollination (Shafqat et al., 2016). On the other hand, several species of the family have medical and veterinary importance (Stevens, 2003).
<table>
<thead>
<tr>
<th>Species</th>
<th>Parameters</th>
<th>Status Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Classification</td>
<td>Obligatory wound myiasis.</td>
</tr>
<tr>
<td></td>
<td>Hosts</td>
<td>Mammals.</td>
</tr>
<tr>
<td></td>
<td>Human Myiasis</td>
<td>Cause human wound myiasis and destroy the underlying tissues because of the screw-like feeding fashion of maggots.</td>
</tr>
<tr>
<td><em>Chrysomya bezziana</em> (Old-world Screwworm)</td>
<td>Distribution</td>
<td>Prefers tropical and subtropical climates and widespread throughout tropical Africa, Middle East region, Indian sub-continent, from south-east Asia to China, and from the Philippines to Papua New Guinea.</td>
</tr>
<tr>
<td></td>
<td>Classification</td>
<td>Obligatory wound myiasis.</td>
</tr>
<tr>
<td></td>
<td>Hosts</td>
<td>Sheep and human.</td>
</tr>
<tr>
<td></td>
<td>Human Myiasis</td>
<td>Human wound myiasis cases were reported in a poor region in Africa and Indian sub-continent.</td>
</tr>
<tr>
<td><em>Chrysomya megacephala</em></td>
<td>Distribution</td>
<td>Has a worldwide distribution especially in Oriental and Australasian regions.</td>
</tr>
<tr>
<td></td>
<td>Classification</td>
<td>Facultative wound myiasis.</td>
</tr>
<tr>
<td></td>
<td>Hosts</td>
<td>Decomposing flesh and feces.</td>
</tr>
<tr>
<td></td>
<td>Human Myiasis</td>
<td>Wound and aural myiasis. Has forensic importance.</td>
</tr>
<tr>
<td><em>Chrysomya albiceps</em> and <em>Chrysomya rufifacies</em></td>
<td>Distribution</td>
<td>Native species in Australia.</td>
</tr>
<tr>
<td></td>
<td>Classification</td>
<td>Facultative wound myiasis flies.</td>
</tr>
<tr>
<td></td>
<td>Hosts</td>
<td>Primary and secondary myiases in humans and other animals.</td>
</tr>
<tr>
<td></td>
<td>Human Myiasis</td>
<td>Wound and Nasal myiasis. Has forensic importance.</td>
</tr>
<tr>
<td><em>Auchmeromyia senegalensis</em> (Congo floor maggot)</td>
<td>Distribution</td>
<td>Mainly distributed in Sub-Saharan Africa.</td>
</tr>
<tr>
<td></td>
<td>Classification</td>
<td>Sanguinivorous myiasis.</td>
</tr>
<tr>
<td></td>
<td>Hosts</td>
<td>Mammals.</td>
</tr>
<tr>
<td></td>
<td>Human Myiasis</td>
<td>Suck human blood.</td>
</tr>
<tr>
<td><em>Lucilia serricata</em> and <em>Lucilia cuprina</em></td>
<td>Distribution</td>
<td><em>Lucilia serricata</em> in North America and Europe and <em>Lucilia cuprina</em> in South Africa and Australia.</td>
</tr>
<tr>
<td></td>
<td>Classification</td>
<td>Facultative wound myiasis.</td>
</tr>
<tr>
<td></td>
<td>Hosts</td>
<td>Prefer dead tissue of sheep and sometimes feed on living tissue.</td>
</tr>
<tr>
<td></td>
<td>Human Myiasis</td>
<td>Facultative wound myiasis.</td>
</tr>
<tr>
<td><em>Calliphora sp.</em></td>
<td>Distribution</td>
<td>Has a worldwide distribution.</td>
</tr>
<tr>
<td></td>
<td>Classification</td>
<td>Facultative myiasis.</td>
</tr>
<tr>
<td></td>
<td>Hosts</td>
<td>Decomposing flesh of carrions</td>
</tr>
<tr>
<td></td>
<td>Human Myiasis</td>
<td><em>Calliphora vicina</em> is primary invader causing oral, aural, nasal, intestinal, urinogenital and wound myiasis. <em>Calliphora hilli</em> cause ocular myiasis.</td>
</tr>
<tr>
<td><em>Cordylobia anthropophaga</em> (Tumbu fly)</td>
<td>Distribution</td>
<td>Sub-Saharan Africa and Portugal.</td>
</tr>
<tr>
<td></td>
<td>Classification</td>
<td>Obligatory cutaneous myiasis</td>
</tr>
<tr>
<td></td>
<td>Hosts</td>
<td>Wild mammals and domestic animals</td>
</tr>
<tr>
<td></td>
<td>Human Myiasis</td>
<td>Furuncular myiasis</td>
</tr>
<tr>
<td><em>Cordylobia rodhaini</em> (Lund’s fly)</td>
<td>Distribution</td>
<td>Tropical Africa especially in humid forests.</td>
</tr>
<tr>
<td></td>
<td>Classification</td>
<td>Obligatory cutaneous myiasis.</td>
</tr>
<tr>
<td></td>
<td>Hosts</td>
<td>Forest mammals particularly rodents.</td>
</tr>
<tr>
<td></td>
<td>Human Myiasis</td>
<td>Occasionally cause furuncular myiasis</td>
</tr>
<tr>
<td><em>Phormia regina</em> and <em>Protophormia terranovae</em></td>
<td>Distribution</td>
<td>The northern area of Tropic cancer.</td>
</tr>
<tr>
<td></td>
<td>Classification</td>
<td>Facultative wound myiasis.</td>
</tr>
<tr>
<td></td>
<td>Hosts</td>
<td>Decomposing flesh and <em>Protophormia terranovae</em> is a serious parasite of cattle, sheep, and reindeer</td>
</tr>
</tbody>
</table>
|          | Human Myiasis | *Phormia regina* is facultative wound myiasis and has forensic importance.
Conclusion

The way is still so far for getting a complete understanding of myiasis relation and extensive investigations are needed in this direction. This work forms a small step in gathering the data of myiasis causing flies especially those belonging to family Calliphorida.

REFERENCES


Kenawy, M.A. (2008). Medical and veterinary entomology. Lectures’ note, Entomology Department, Faculty of Science, Shams University, Cairo, Egypt.


Laurence, S.M. (1909). Dipterous larvae infection. BM.J., 9-88


ARABIC SUMMARY

مراجعه موجزة و شامله لظاهره التدويد مع الالقاء الضوء علي الذباب الدافع والتابع لعائلة الخوتعيات

إسلام محمد حسني؛ محمد أمين قناوي؛ محمد جمال الدين ناصر؛ ماجده حسن راضي
قسم غلم الحشرات – كلية العلوم – كلية عين شمس، البحوث، القاهرة 11566، مصر

تعتبر ظاهره التدويد واحدة من العلاقات الأكثر تعقيدا و إثارة للاهتمام في الطبيعه. وذلك لطبيعه العلاقة المركبة بين طرفين؛ الأول هو يرقات الذباب والطرف الآخر هو الانسجع الحية التي تتغذي عليها من العائل الحي. وقد ناقشت العديد من الابحاث العلميه السابقة ظاهره التدويد من جوانب مختلفة. وبعد هذا العمل مراجعة موجزة و شاملة لظاهره التدويد بما في ذلك الإقسام والأنواع المختلفة لتلك الظاهرة وكذلك، تصنيف برياقات الخوتعيات من رتبة ثانيايات الأجنحة و السببية لظاهرة التدويد.