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Two new records of flies causing myiasis from Saudi Arabia with a survey of flies parasitizing goats and sheep in Jazan Region

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Abstract. Despite the medical, veterinary and forensic relevance of myiasis-causing flies, knowledge of their diversity in Saudi Arabia is limited especially in the southern region. Therefore, a survey of myiasis-causing flies in the Jazan region was carried out using Red Top Fly Catcher traps baited with either decomposing beef liver or a lure composed primarily from fishmeal during the period April 2013-March 2014. Twelve known species were identified and recorded in this study, seven species of them belonging to Calliphoridae (*Chrysomya*, *Lucilia*, and *Hemipyrella*) and five species belonging to Sarcophagidae (*Sarcophaga*). Two of these species were recorded for the first time for Saudi Arabia, namely *Hemipyrella pulchra* (Wiedemann, 1830) and *Sarcophaga* (*Liosarcophaga*) *exuberans* Pandellé, 1896. Images of the species recorded are also provided for the first time. The results expand the knowledge of geographical distribution, fauna, and habitat of the myiasis-causing flies in Saudi Arabia. Biological information and world-wide geographical distribution of these species are included together with some taxonomic remarks.

INTRODUCTION

Myiasis is the infestation of living tissue of humans and other animals with dipterous larvae (Zumpt, 1965). The term includes the infestation of the gut, lung or other internal organs with Dipterus maggots. Myiasis causes irritation (biting and rubbing the affected sites), annoyance to animals, disruption of normal habits and responsible for severe economic losses to the livestock industry in developing and developed countries. The most important effects of such dipterous invasion including bacterial secondary infection, abortion, reduction of milk production, losses in weight and fertility and finally the total death of the animal (Rafinejad *et al.*, 2014; Otranto & Colwell, 2008). On the other hand, myiasis-causing larvae have attracted the attention of scientists because some of them accidentally attacked humans and have a great interest in forensic entomology (Vasconcelos *et al.*, 2014).

There are six families of flies which discriminated to causing such phenom: Calliphoridae, Sarcophagidae, Oestridae, Hypodermatidae, Gasterophilidae, and Phoridae. Some other species of Muscidae and Psychodidae may also cause myiasis rarely (Serra-Freire & Mello, 2006; Hosni *et al.*, 2019). This phenomenon occurs worldwide with a seasonal variation that is related to the latitude and the life cycle of certain species of flies (Schneider *et al.*, 2007). Myiasis is restricted to the summer months in temperate zones while it is all year round with a high incidence rate in the

tropics, south-east Asia and the subtropics of Africa as the flies causing myiasis prefer a warm and humid environment (Hall & Wall, 1995; Frikh *et al.*, 2009; Junior *et al.*, 2010).

The myiasis-causing flies in Saudi Arabia and especially from the southern region are poorly known and have not been sufficiently explored, apart from the paper by Bosly (2010), reported the presence of some species of these flies such as *Chrysomya albiceps* (Wiedemann), *Chrysomya marginalis* (Wiedmann), *Sarcophaga ruficornis* (Fabricius), *Sarcophaga dux* Thompson and *Wohlfahrtia indigens* Villeneuve. Almost all our knowledge of myiasis-causing flies is derived from studies outside Saudi Arabia, with the exception of some surveys on the central region of kingdom especially Asir province (Ansari & Oertley, 1982; Alahmed, 2004; Abo Shehada, 2004; Dawah & Abdullah, 2005, 2009). Therefore, the objective of the present work is to report on our investigation of flies causing myiasis in the Jazan region, together with updating our knowledge along with new records for the kingdom, some biological aspects, distribution of the species and taxonomic remarks.

MATERIALS AND METHODS

The study area

Jizan, one of the Kingdom's richest agricultural regions, lies in the southwest corner of Saudi Arabia, remarkable for both the quality and variety of its agricultural production (Fig. 1a). It is also heavily populated with sheep and goats. Jizan areas consist of fertile plains, open woodland interspersed with some areas of rich pasture and mountains, which are part of the Al sarawat mountain range which constitutes the jagged backbone of the Arabian Peninsula. The highest peak in Jizan is the Fifa Mountain, which is 11,000 feet. Jazan has a hot desert climate with the highest recorded temperature of 49 C in July while the lowest is 9 C in February.

Collection of adult myiasis-causing flies from the study area

Five collection sites representing different ecological zones in Jazan Region were selected for collection of myiasis-causing flies (Fig. 1a), these are: Abu Areish (16.92440 °N, 42.81286 °E), Al Husseini Farm, (16.95080 °N, 42.63079 °E), Sabya, (17.17157

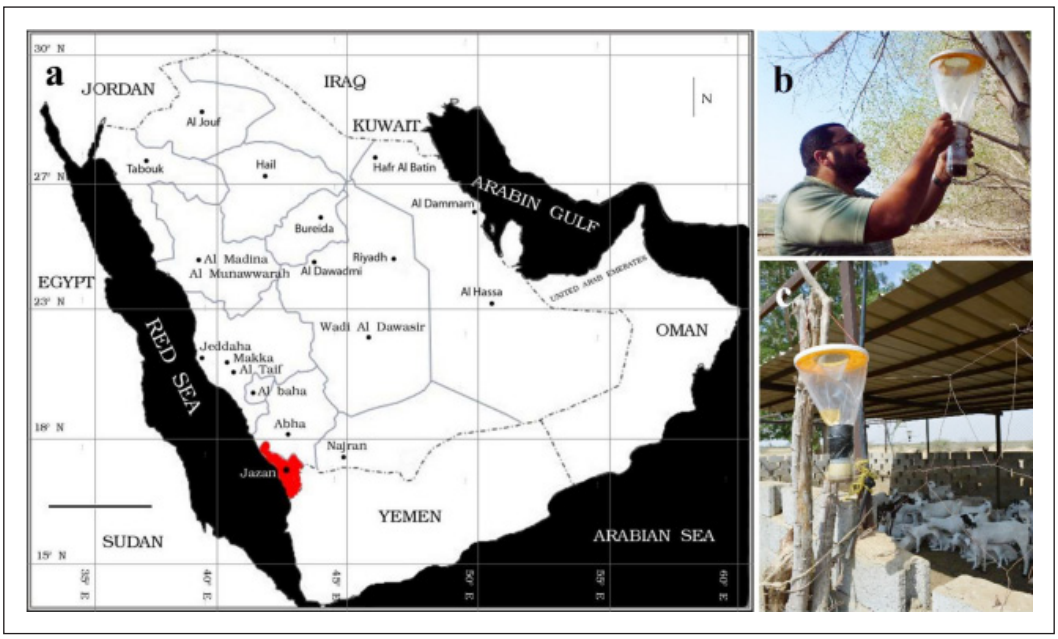

Figure 1. a. Saudi Arabia map showing Jazan in red color; b. 2nd author inserting red top flycatcher in a farm near Beish; c. Red top flycatcher hanged in goat pen in Sabia.

°N, 42.69 821 °E), Beish, (17.38123 °N, 42.48549 °E) and Mahliya (16.95113 °N, 42.62968 °E). In each collection site, two Red Top Fly Catcher traps (Matthew Hicks, Ashmoat Ltd, Suffolk, U.K.) baited with decomposed beef liver and another two Red Top Fly Catcher traps baited with the lure (adult attractant formulated by the manufacturing company which is mainly fish powder) were set up (Fig. 1b&c). The four baited traps were set up in each collection site every two weeks, for 12 months (from April 2013-March 2014), and trapped flies were collected 4-5 days post each set up of traps. Attracted adult flies in each trap in each collection site were taken out, put into a Petri dish, labeled, tightly closed and kept for identification under refrigeration.

Identification of adult flies and their distribution

All adult flies collected were initially sorted to family, genus, and species using Zumpt (1965), Hall & Smith (1993), Deeming (1996), Rognes (2002) and Setyaningrum & Al Dhafer (2014) for Calliphoridae; Zumpt (1965), Hall & Smith (1993) and Rohdendorf (1970) for Sarcophagidae. Where necessary genitalia dissection was made to establish an identity as described by Deeming (1996). The dissected organs were preserved with the individual specimens. Representative specimens of adult flies were identified by Dr. J. C. Deeming, National Museum of Wales, Cardiff, (NMWC), United Kingdom. Voucher specimens of all the species identified in this study were deposited in the King Saud University Collection of Arthropods (KSUCA), Centre for Environmental Research and Studies (CERS) and National Museum of Wales Cardiff (NMWC). The distribution maps created using DIVA-GIS free software v.7.5. using the heritage data of species records and distribution available through Shalaby 1962; Büttiker *et al.*, 1979; Pont 1980; Dear 1980; Schumann 1986a; Walker & Pittawy 1987; Amoudi 1993; Hall & Smith, 1993; Deeming 1996; Verves 2003, 2004; Hira *et al.*, 2004; van Harten 2005; Deeming 2007; Rueda *et al.*, 2010 and Youssefi *et al.*, 2012.

RESULTS

Twelve known species of myiasis-causing flies were identified and recorded in this study, two of which were recorded for the first time from Saudi Arabia namely: *Hemipyrellia pulchra* (Wiedemann, 1830) (Calliphoridae); *Sarcophaga* (*Liosarcophaga*) *exuberans* Pandellé, 1896 (Sarcophagidae). Biological information and world-wide geographical distribution of these species are included together with some taxonomic remarks. In addition to the results of the identifications, all available literature about myiasis-causing flies of Saudi Arabia is summarised.

Species accounts

Calliphoridae

Subfamily Chrysomyinae

Chrysomya albiceps (Wiedemann, 1819) (Fig. 2a; 3a)

Musca albiceps Wiedemann, 1819: Zoologisches Magazin. Kiel 1 (3): 38

Pont (1980: 788) listed eleven synonyms.

Specimens examined: Saudi Arabia: long series of ♂ and ♀, Jazan, Abu Areish, Al Husseini Farm, Sabya, Beish, Mahliya, baited traps, every month from April 2013-March 2014, M. Nasser & M.F. Sallam.

Remarks: Larvae necro- and coprophilous, predators of larvae of other Diptera (e.g., *Musca stabulans* Fallén, 1817) (Omar, 1995). It is very closely related to *C. rufifacies* (Macquart, 1843) and may be confused with it by inexperienced taxonomists (Verves, 2004). *C. albiceps* prefers hot and moist conditions (Büttiker *et al.*, 1979). It is reported to breed in dung, dead animals (e.g. leopard, dog, and porcupine) and faeces (e.g. sheep and goats), and produces facultative cutaneous myiasis in livestock, goats, donkey, sheep, camels, and men (Greenberg, 1971, 1973), following an initial strike by *Lucilia* species. Adults could be a nuisance in houses, markets, food shops, hospitals and slaughter-houses (Büttiker, *et al.*, 1979). Summarised information on biology, distribution and synanthropic significance of *C. albiceps* can be found in Zumpt (1965); Madeira (2001); Rognes (2002); Verves (2004); Hall & Smith (1993) and Dawah & Abdullah (2009).

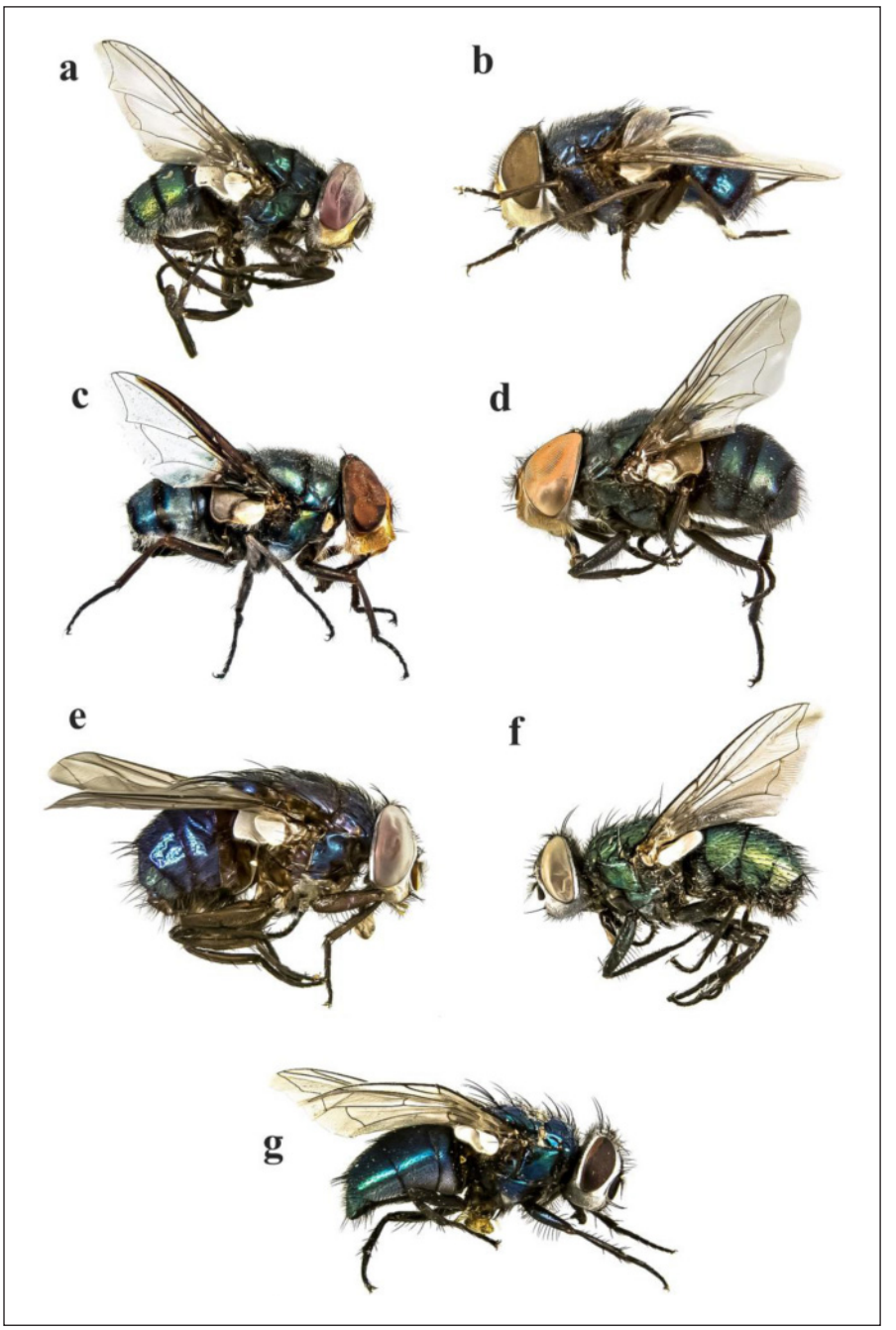

Figure 2. Flies of family Calliphoridae: a. *Chrysomya albiceps*; b. *Chrysomya bezziana*; c. *Chrysomya marginalis*; d. *Chrysomya megacephala*; e. *Hemipyrellia pulchra*; f. *Lucilia cuprina*; g. *Lucilia sericata*. Copy righted to Authors.

Chrysomya bezziana Villeneuve, 1914 (Fig. 2b; 3b)

Chrysomya bezziana Villeneuve, 1914: Revue Zoologicalique Africaine 3: 430

Specimens examined: Saudi Arabia: Long series of ♂, ♀, Jazan, Beish, baited traps, every month from April 2013-March 2014, M. Nasser & M.F. Sallam (KSU).

Remarks: This species is more common in India than in Africa (Zumpt 1965). The

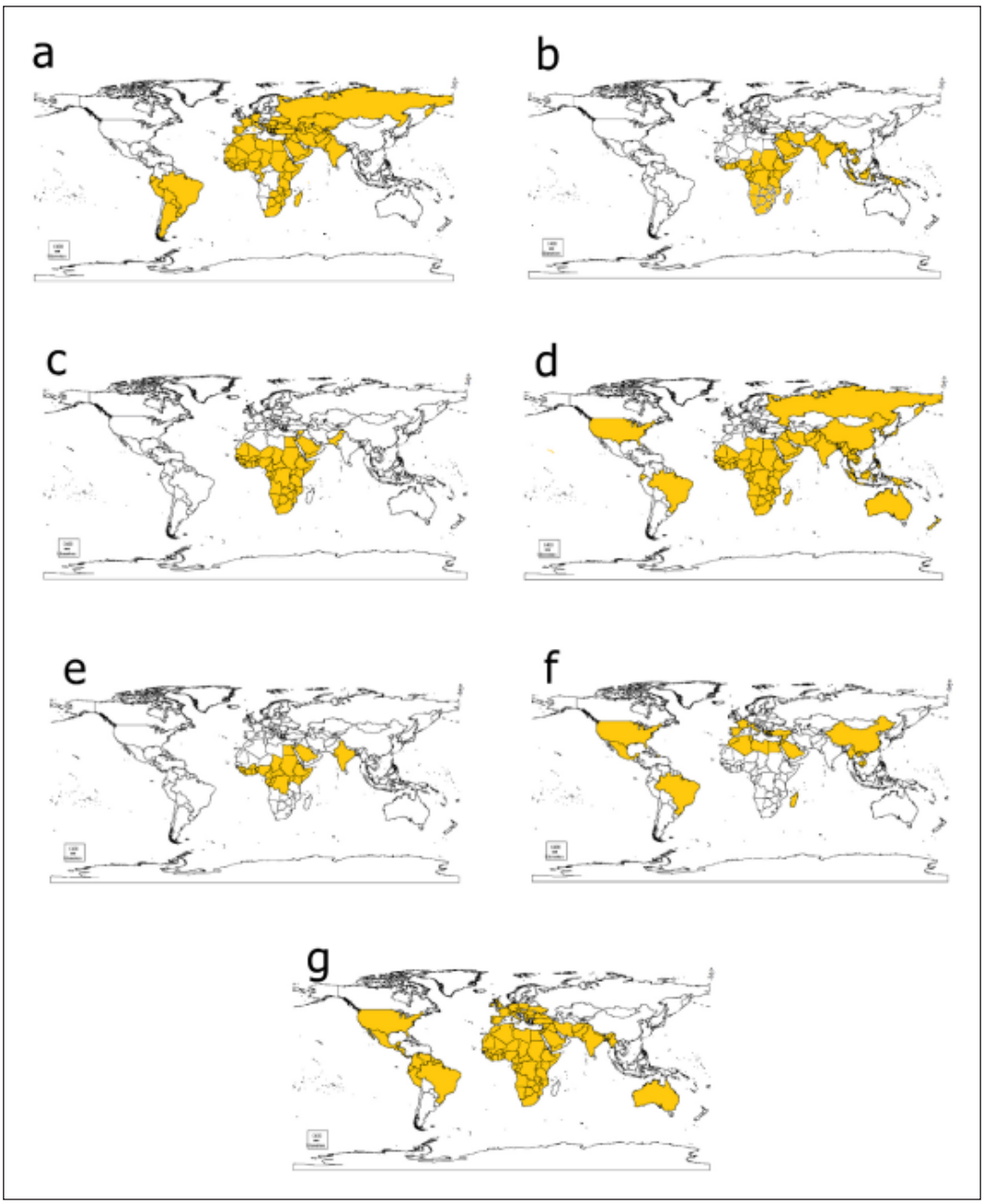

Figure 3. World distribution maps of Flies of family Calliphoridae: a. *Chrysomya albiceps*; b. *Chrysomya bezziana*; c. *Chrysomya marginalis*; d. *Chrysomya megacephala*; e. *Hemipyrellia pulchra*; f. *Lucilia cuprina*; g. *Lucilia sericata*.

female lays 150-500 eggs at a time at wound sites or in body orifices, (nose, mouth, ear, and orbit) of live mammals as obligate parasitic flies requiring a host to complete their development (Hall & Smith, 1993; Hosni *et al.*, 2020). The larvae feed on host tissue, attracted to blood and after completing their developments they drop to the ground to pupate. The adults are rarely found in the field (Zumpt, 1965). The adults feed on decomposing corpses, decaying matter, excreta and take nectar from flowers.

Therefore, the adult flies can be a mechanical vector for pathogens because of their diet. This species has not been used in maggot therapy because the larvae aggressively burrow through living tissue and can cause permanent tissue-damage. It is not suitable for use in forensics because it can cause myiasis on a live mammal and this means the time of colonization is not always concurrent with the time of death (Sukontason *et al.*, 2005).

Chrysomya marginalis (Wiedemann, 1830) (Fig. 2c; 3c)
Musca marginalis Wiedemann 1830: Aussereuropäische zweiflügelige Insekten2: 395.
Pont (1980: 789) lists three synonyms for *C. marginalis*.
Specimens examined: Saudi Arabia: long series of ♂ and ♀, Jazan, Abu Areish, Al Husseini Farm, Sabya, Beish, Mahliya, baited traps, every month from April 2013-March 2014, M. Nasser & M.F. Sallam.
Remarks: *C. marginalis* is a carrion breeder. It is well established in Israel (Rognes, 2002) and Egypt (Schumann, 1986b). Zumpt (1965: 96) reported that the breeding record of larvae found in the malformed horns of a dying ox in Kenya as being the only reliable one for *C. marginalis*. *C. regalis* is recorded from Saudi Arabia by Dabbour (1979), but that species has been placed as a synonym for *C. marginalis* (Rognes, 2002: 13).

Chrysomya megacephala (Fabricius, 1794) (Fig. 2d; 3d)
Musca megacephala Fabricius, 1794: Entomologia Systematica 4: 317
Pont (1980: 789) lists four synonyms of this common species.
Specimens examined: Saudi Arabia: long series of ♂ and ♀, Jazan, Abu Areish, Al Husseini Farm, Sabya, Beish, Mahliya, baited traps, every month from April 2013-March 2014, M. Nasser & M.F. Sallam.
Remarks: This species is a common scavenger breeding in faeces, decaying meat, carrion, corpses of pigs, dogs, toads, rats, frogs, essentially saprophagous, breeding in decomposing animal matter (Verves, 2003). It is occasionally a causative agent of cutaneous myiasis of different living mammals and man (Hall & Smith, 1993; Zumpt, 1965). It is known as the Oriental latrine fly. It is of little use in forensics because it can cause myiasis in the absence of necrotic tissue and therefore, it can be difficult to determine the time of colonization (Sukontason *et al.*, 2005). It is a nuisance when it is present in large number on fish markets, slaughterhouses and open-air meat markets (Hall & Smith, 1993). Adults swarms on meat and sweets, with a notable attraction to fish. Under insanitary conditions, it is likely to transmit enteric pathogens and parasites (Zumpt, 1965; Green, 1971, 1972; Kurahashi, 1982; Kurahashi & Chowanadisai, 2001).

Subfamily Luciliinae
Hemipyrellia pulchra (Wiedemann, 1830) (Fig. 2e; 3e)
Musca pulchra Wiedemann, 1830: Aussereuropaische zweiflügelige Insekten 2: 406.
Pont (1980:793) lists one synonym.
Specimens examined: Saudi Arabia: long series of ♂ and ♀, Jazan, Abu Areish, Al Husseini Farm, Sabya, Beish, Mahliya, baited traps, every month from April 2013-March 2014, N.M. Gamal & M.F. Sallam.
Remarks: It may be an insect of forensic importance. In Thailand, it was found among carrion calliphorid insect in low numbers (Moophayak, *et al.*, 2014).

Lucilia cuprina (Wiedemann, 1830) (Fig. 2f; 3f)
Musca cuprina Wiedemann, 1830: Aussereuropaische zweiflügelige Insekten2: 654
Eight synonyms are listed in Pont (1980: 793).
Specimens examined: Saudi Arabia: long series of ♂ and ♀, Jazan, Abu Areish, Al Husseini Farm, Sabya, Beish, Mahliya, baited traps, every month from April 2013-March 2014, M. Nasser & M.F. Sallam.
Remarks: Most species in the genus *Lucilia* are saprophagous in vertebrate carrion, with some tending primarily to attack live sheep, and one (possibly more) that attacks live Amphibian (Ferrar, 1987). Ferrar (1987) reported that *L. cuprina* is the sheep blowfly, particularly of Australia and South Africa,

where it is a major veterinary pest in sheep-raising areas. It causes primary myiasis of previously uninjured sheep, and this damage may then be secondarily invaded and enlarged upon by other Calliphoridae. The species breeds in carrion to a much lesser extent but is principally an agent of myiasis. The flies are attracted to sheep which have areas of soiled fleece or are suffering from bacterial decomposition of the fleece in fleece rot. The female lays her eggs in sores or cuts in the sheep's skin and the larvae develop there, eating the sheep's flesh away with alarming rapidity. Heavy infestations may kill sheep. The adults feed on fallen fruit, nectar, the honeydew of aphids but also on faeces of sheep and other animals to obtain a protein meal, which is important for maturing the eggs (Webber, 1958). The larvae rarely develop in faeces and the adults only occasionally land on man to feed on sores or secretions (Hall & Smith, 1993). Kettle (1992: 249) summarised existing knowledge of the biology, behaviour, bionomics and the effect of *L. cuprina* on sheep.

Lucilia sericata (Meigen, 1826) (Fig. 2g; 3g)
Musca sericata Meigen, 1826: Systematische Beschreibung der bekannten europaischen zweiflügeligen Insekten 5: 53
Pont (1980: 794) lists three synonyms.
Specimens examined: Saudi Arabia: long series of ♂ and ♀, Jazan, Abu Areish, Al Husseini Farm, Sabya, Beish, Mahliya, baited traps, every month from April 2013-March 2014, M. Nasser & M.F. Sallam.
Remarks: There are several factors which play a role in the development of *L. sericata* including the temperature, food source, and humidity (Tarone & Foran, 2006). After mating, females lay up to 200 eggs at a time, on the host or carcass. *L. sericata* plays an important role in (a) veterinary medicine as the larval of *L. sericata* can cause a form of myiasis known as a sheep strike or blowfly strike, mainly in Northern and Central Europe with substantial losses in animals and production (Strikewise, 2007), (b) medical treatment using the larvae of *L. sericata* to heal injuries by not only eating the decomposing tissue but also secreting and producing antimicrobial enzymes while in the wound (Rueda *et al.*, 2010; Horobin *et al.*, 2002), (c) forensic science as the larvae help to determine the period of insect colonization, as it relates to the time of death, aiding law enforcement in their investigations (Rueda *et al.*, 2010).

Sarcophagidae
Subfamily Sarcophaginae

Sarcophaga* (*Liosarcophaga*) *exuberans Pandellé, 1896 (Fig. 4a; 5a)
Sarcophaga* (*Liosarcophaga*) *exuberans Pandellé, 1896: Revue Entomologie 15: 186.
Pont (1980: 815) lists three synonyms.
Specimens examined: Saudi Arabia: long series of ♂ and ♀, Jazan, Abu Areish, Al Husseini Farm, Sabya, Beish, Mahliya, baited traps, every month from April 2013-March 2014, M. Nasser & M.F. Sallam (KSU).
Remarks: The biology of *S.* (*Liosarcophaga*) *exuberans* is unknown. The only rearing record of *S.* (*Liosarcophaga*) *exuberans* was from a dead snake in the Gambia (J.C. Deeming, per.comm.). Salem (1935: 55) records it as *Sarcophaga dux* Thomson var. *exuberans* Pandellé. It has since been elevated to the status of species. Also, *Thyrsocnema* Enderlein 1928 is now placed as a junior synonym of *Liosarcophaga* Enderlein 1928, therefore, we use *Liosarcophaga* rather than *Thyrsocnema*.

***Sarcophaga (Bercaea) africa* (Wiedemann, 1824)** (Fig. 4b; 5b)
Musca africa Wiedemann, 1824
syn. Sarcophaga cruentata (Meigen, 1826)
syn. Sarcophaga haemorrhoidalis auctt. Nec Fallén, 1817
Dear (1980: 811) lists five synonyms.
Specimens examined: Saudi Arabia: long series of ♂ and ♀, Jazan, Abu Areish, Al Husseini Farm, Sabya, Beish, Mahliya, baited traps,every month from April 2013-March 2014 April, M. Nasser & M.F. Sallam.
Remarks: Formerly known by the names *S. haemorrhoidalis* Fallén and *cruentata* Meigen (Gennard, 2007), this species may serve as a mechanical vector for pathogens, especially if it enters homes. In Iran, it was reported to cause auricular myiasis on the

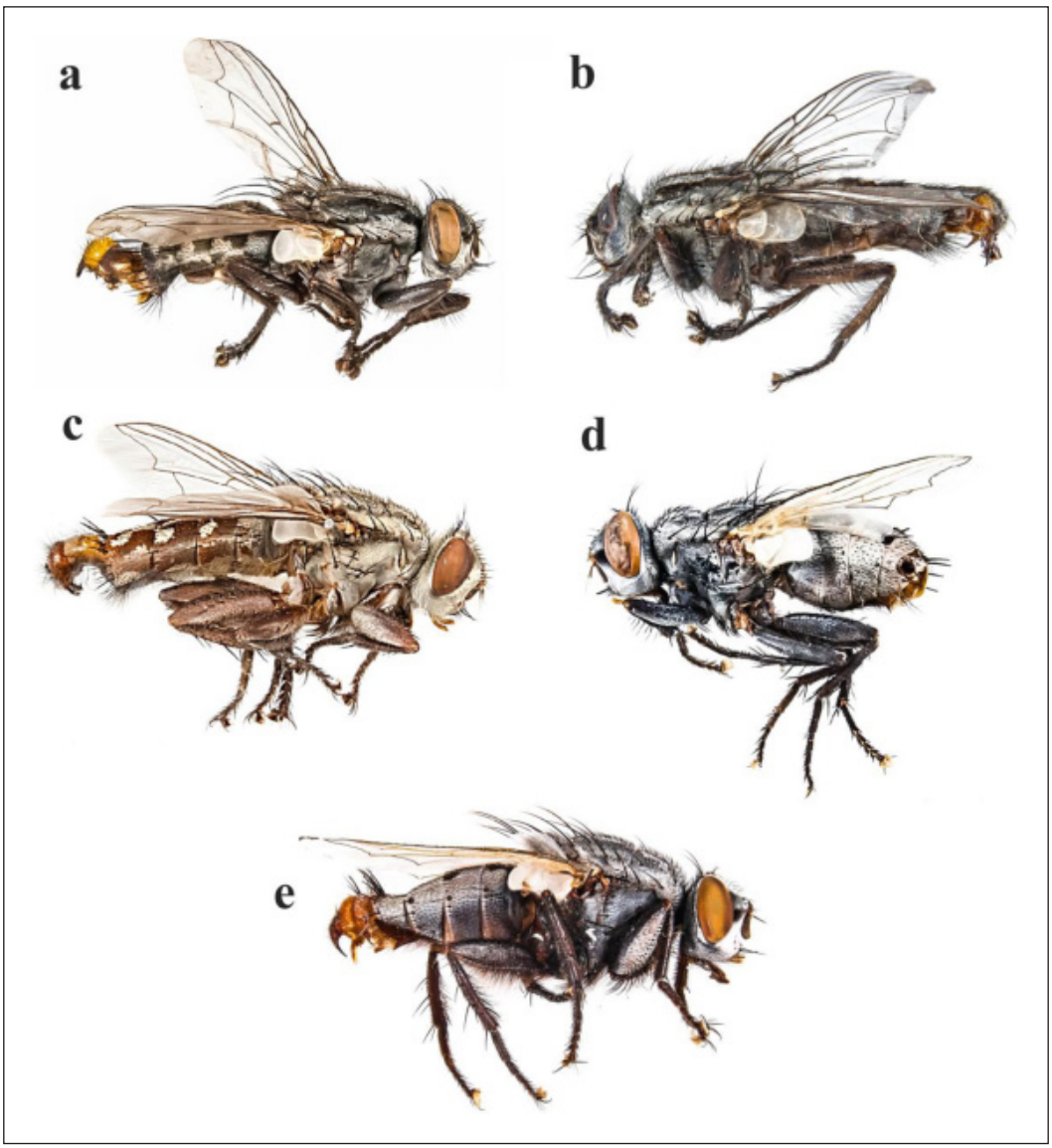

Figure 4. Flies of family Sarcophagidae: a. *Sarcophaga exuberans*; b. *Sarcophaga haemorrhoidalis*; c. *Sarcophaga hirtipes*; d. *Wohlfahrtia nuba*; e. *Wohlfahrtia indigens*. Copy righted to Authors.

outer ear of human (Tigar & Khalkhali, 1977). It causes accidental myiasis when meat contaminated with live larvae is eaten and the larvae reach the gastrointestinal tract and infest the intestines (Smith, 1986). The larvae could be used in forensic investigations if the pupation and lifecycle times are known, thus allowing investigators to calculate how long the fly has been on the corpse (Byrd & Butler, 1998).

Sarcophaga* (*Parasarcophaga*) *hirtipes
Wiedemann, 1830 (Fig. 4c; 5c)
Sarcophaga hirtipes Wiedemann, 1830: Aussereuropaische zweiflugelige Insekten2: 361

Specimens examined: Saudi Arabia: long series of ♂ and ♀, Jazan, Abu Areish, Al Husseini Farm, Sabya, Beish, Mahliya, baited traps, every month from April 2013-March 2014, N.M. Gamal & M.F. Sallam.

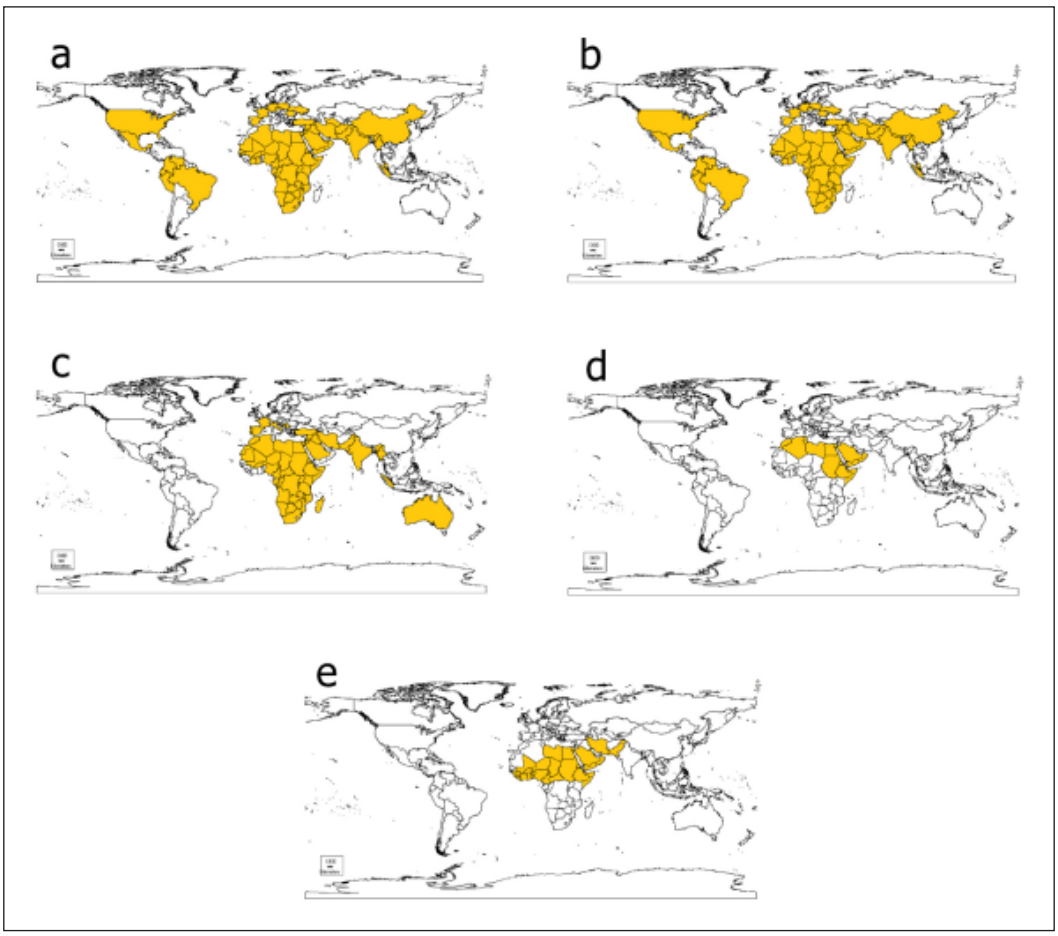

Figure 5. World distribution maps of Flies of family Sarcophagidae: a. *Sarcophaga exuberans*; b. *Sarcophaga haemorrhoidalis*; c. *Sarcophaga hirtipes*; d. *Wohlfahrtia nuba*; e. *Wohlfahrtia indigens*.

Remarks: The larvae of *S.* (*Parasarcophaga) hirtipes* develop in corpses, faeces, and meat. It produces intestinal myiasis in man (Verves, 2003). Cuthbertson (1933) reported that the larvae of *S. hirtipes* were found in wounds of cattle and sheep but he stated that it does not appear to cause myiasis in Zimbabwe. However, the adults of *S.* (*Parasarcophaga*) *hirtipes* have been reared from fully-grown larvae causing human intestinal myiasis in Egypt (Salem, 1935). Büttiker *et al.* (1979) reported that *S. hirtipes* larvae are frequently found in wounds of animals and in human excrement and in animal corpses and plant material. Adults are attracted to faeces, corpses and other decomposed animal and plant matter (Sychevskaya, 1960; Greenberg, 1971; Salva & Abdul-Rahman, 1983).

Wohlfahrtia nuba (Wiedemann, 1830) (Fig. 4d; 5d)

Tachina nuba Wiedemann, 1830: Ausser-europaische zweiflugelige Insekten2: 296. Pont (Dear: 816) lists one synonym.

Specimens examined: Saudi Arabia: long series of ♂ and ♀, Jazan, Abu Areish, Al Husseini Farm, Sabya, Beish, Mahliya, baited traps, every month from April 2013-March 2014, N.M. Gamal & M.F. Sallam.

Remarks: This species occurs in dry climates of the Palaearctic and Oriental regions. *W. nuba* has been found to cause traumatic myiasis in man and animals, especially camels in North Africa and the Middle East (Salem, 1938; Lewis, 1955). According to Grantham-Hill (1933) and James (1947), the larvae feed only on the dead or diseased

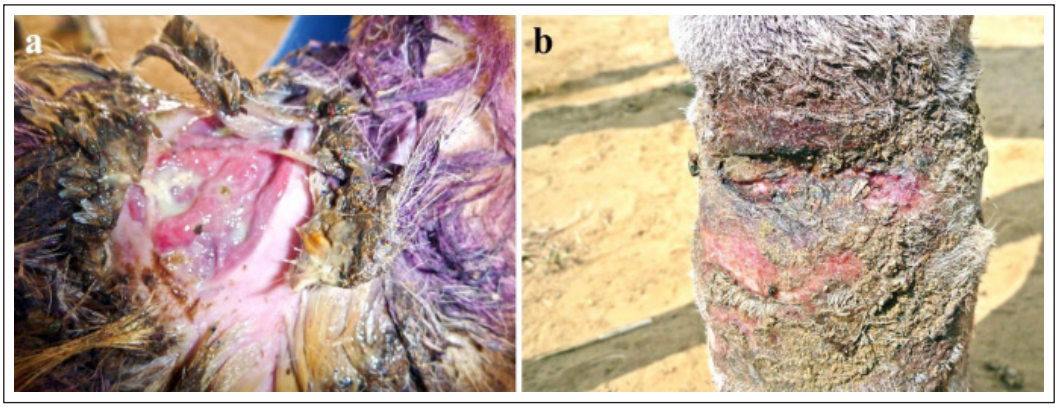

Figure 6. Myiasis cases reported during the present work in Beish, Jazan: a. Myiasis on sheep back "violet color represents antimicrobial treatment to decrease the effect of infection"; b. A rare case of the infected leg of a camel.

tissue rather than on living tissues. Therefore, it has been used in the treatment of slow-healing wounds, as has been done with *Lucilia sericata* (Diptera: Calliphoridae) in the U.S.A. even though it can cause myiasis in man and domestic animals (Zumpt, 1965). Salem (1938) reported that *W. nuba* to have been reared from dead locusts. For records and notes on immature stages see James (1947), Zumpt (1965) and Hilton (1973).

Wohlfahrtia indigens Villeneuve, 1928 (Fig. 4e; 5e)
Wohlfahrtia indigens Villeneuve, 1928: Bulletin et Annales de la Société Royale Entomologique de Belgique 68: 49
Dear (1980: 816) lists one synonym.
Specimens examined: Saudi Arabia: long series of ♂ and ♀, Jazan, Abu Areish, Al Husseini Farm, Sabya, Beish, Mahliya, baited traps, every month from April 2013-March 2014, N.M. Gamal & M.F. Sallam (KSU).
Remarks: The biology of *W. indigens* is completely unknown but it could be an agent of myiasis (Büttiker *et al.*, 1979).

DISCUSSION

In the course of this survey of flies causing myiasis in the Jazan region, 12 species were found, seven of them belonging to Calliphoridae (*Chrysomya*, *Lucilia*, and *Hemipyrella*) and five species belong to Sarcophagidae (*Sarcophaga*). Of the 12 species, two of these species were recorded for the first time for Saudi Arabia namely; *H. pulchra* (Calliphoridae), *S.* (*Liosarcophaga*) *exuberans* (Sarcophagidae). The results are of significance in confirming the presence of 12 species, 10 of them associated with myiasis. There are few species of flies causing myiasis known from Jazan (Bosly, 2010), but the presence of adult oriental screw worm *C. bezziana* confirm cases of myiasis in the region. Some infestation has already recorded during this study especially from Beish (Fig. 6).

This study demonstrates the occurrence of flies causing myiasis all year round due to the favorable environmental conditions in the Jazan region. Also, the species of flies causing myiasis were found in all the sites of study with exception *C. bezziana* which found only in the Beish site. This is not surprising as the adults of *C. bezziana* are rarely found in the field (Zumpt, 1965). The data presented here serves to illustrate how little is known of the biology of this important group of myiasis-causing flies in Saudi Arabia, and Jazan region in particular. Therefore, collecting and identifying the flies causing myiasis in Jazan area is of considerable importance. The number of flies causing myiasis recorded in this study is expected to increase if further intensive

and careful collections are made. Dawah & Abdullah (2005) have emphasized the importance of faunistic studies on local insects to obtain information that will help the authorities to design more effective and more efficient control of economically important insects. It will be essential to investigate the distribution, seasonal dynamics, diurnal activity, modes of infestation, biotic and abiotic factors influencing the phenology using modern techniques such as geographical information system (GIS) and molecular biology of these flies and that could be published elsewhere.

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