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The First Annotated Checklist of Parasites Infecting the One-Humped Camel, *Camelus dromedarius* (Artiodactyla: Camelidae), of Saudi Arabia Between 1950-2021

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ABSTRACT

Based on the published works of camels in Saudi Arabia, this study is the first checklist of parasites infecting the one-humped camel, Camelus dromedarius in Saudi Arabia between 1950-2021. The present checklist was organized taxonomically in which consist of 75 names representing 4 groups of parasites. The first group was Protozoa with 24 names. Secondly, 13 names of nematodes were reported, while there were 12 names of Platyhelminthes. The last group belongs to the Arthropoda which consists of 26 reported species, most of which belong to Ixodida (Arachnida: Acari). Based on the resulting checklist, the geographical sampling of these records focuses mainly on the Central, Western, Eastern, and Southern regions, respectively. To date, a few studies have recorded parasites in the North region. The evidence reviewed in this list seems to suggest that further research should be undertaken to investigate the biodiversity of parasites infecting camels from the northern region of Saudi Arabia, which is connected to other continents of Asia, Africa, and Europe.

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INTRODUCTION

Camels belong to the family of Camelidae Gray, 1821. It consists of 2 subfamilies: the New World Camelids (Laminae) and Old-World Camelids (Camelinae). The New World Camelids, also known as small camelids, consist of 4 species representing 2 genera that occupied South America. The genus Lama Cuvier, 1800 with the species L. glama, L. guanicoe, and L. pacos, while the genus Vicugna Lesson, 1842 consists of one species V. vicugna (Wilson & Reeder, 2005).

The Old-World Camelids, also known as large camelids, are in 2 domesticated species belonging to the genus of Camelus Linnaeus, 1758. The first species is known as the dromedary or one-humped camel, Camelus dromedarius Linnaeus, 1758. Its biodiversity is in the hot zone in regions of Africa and the Middle East. The second species is called the two-humped camel or Bactrian camel (C. bactrianus). It inhabits the cold region of China and Central Asia (Al-Swailem et al., 2007; Kadim et al., 2013). The one-humped camel, C. dromedarius, is one of the most diverse camels. Based on the FAOSTAT (2020), the number of camels recorded is approximately over 35 million. Over 90% of the estimated world's camel population was thought to be C. dromedarius (Yam, 2015).

Camels are important animals in Saudi Arabia. They are considered as a significant source of food where people consume their milk and meat (Kadim et al., 2013). Recently, the government of Saudi Arabia adopted many official racing events and beauty contests for camels through the Saudi Camel Federation and Camel Club. The anatomical and physiological characteristics of camels make people use them for transportation in rural areas. Their hump filled with fat gives them the ability to store energy and used them during periods of food limitations. Their thick feet with leathery pads prevent them from walking in the warm sands. The most important characteristic is their ability to water resilience and desaturation of exhaled air in their nose. All these characters made people call the camel "ship of dessert" (Hoter et al., 2019; Yam, 2015).

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Because of the high abundance of C. dromedarius, the government of Saudi Arabia started a new program via the Ministry of Environment, Water, and Agriculture to label and count all camels in the country starting from 2018. Based on the most updated numbers in 2021, the number of labeled camels in Saudi Arabia is 1,581,956. This number increased into about 1,800,000 camels (Ministry of Environment Water and Agriculture, 2021). Besides the efforts of the Saudi government, private businesses and researchers contributed to save and understand camels. For example, the Salam Veterinary Group was established in 2020 with investments exceeding 150 million riyals (40 million dollars). It is the largest and first private veterinary research and treatment company in the world focusing on camels. It is located on an area of 70,000 Square feet in Buraydah, Qassim region with a capacity to house more than 4000 animals. Owners of camels from other countries treat their sick camels in this hospital such as Kuwait, United Arab Emirates, Bahrain, and Qatar (The official Saudi Press Agency, 2020).

Parasitologists, on the other side, tried to make efforts to understand the biodiversity of parasites infecting camels in Saudi Arabia. The earliest published work documenting parasites in camels was done by Hussein et al. (1982). They documented protozoa and nematodes from different localities based on the morphological approach. However, most of the following studies focused on a limited geographical area as shown later. Previously published studies are limited to survey and document parasites of the one-humped camel from the North region of Saudi Arabia.

The present review aims to build a checklist of all parasites recorded and isolated from camels in Saudi Arabia between 1950-2021. This checklist will help future studies as an initial guide to understand the current knowledge of parasite biodiversity infecting camels in Saudi Arabia. This study highlighted the gap in the geographical sampling to help future researchers contribute to the survey and collection of parasites from Saudi Arabia.

METHODS

The records were searched using electronic databases covering the period 1950-2021 such as such as Google Scholar and ISI Web of Science. The relative keywords to the objective of this paper were used. Keywords used in the research include (Camel OR Camelus dromedarius) AND (parasites OR parasite OR nematodes OR nematodes OR Nematoda OR Platyhelminthes OR ticks OR tick) AND (Saudi Arabia).

This study utilized the PRISMA protocol (Figure 1) to build the systematic review (Moher et al., 2009). The resulted publications were organized in Microsoft Excel v.16.58 (Microsoft, Redmond, Washington) for further descriptive analysis. A major advantage of Microsoft Excel is that it allows to count each category and calculate their percentages. The duplicated papers were excluded using EndNote v.20.4 (The EndNote Team, 2013).

The resulting records of parasites were ordered in their taxonomy after they were grouped into 4 major groups of parasites found in the records. In some reports, they provided specific localities while other studies mentioned the locality based on the region only. Both specific and general localities were included in this review.

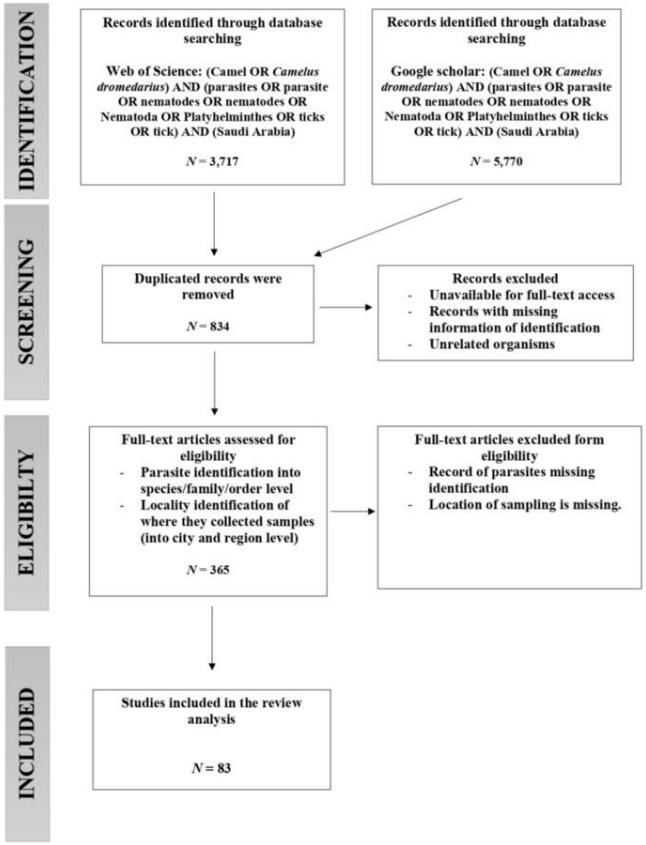

Figure 1. Screening process for eligible articles in this study based on PRISMA protocol

RESULTS AND DISCUSSION

The dataset included 300 records of parasites isolated from *Camelus dromedarius* between 1950-2021. As shown in Table 1, the majority of records belong to endoparasite, 122 (40%) Protozoan have recorded, followed by 110 records (36%) for ectoparasites. It was reported that the helminth parasites were 47 (15%) records of Nematoda and 21 (7%) records of Platyhelminthes. (Figure 2).

Table 1. Numbers of all Records of Parasites from The One-Humped Camel, *Camelus dromedarius* in Saudi Arabia between 1950-2021. The Number was Organized Based on Geographical Regions and Categories of Parasites.

	North	South	Center	East	West	Total
Endoparasites:						
Protozoa	12	19	54	22	15	122
Nematoda	2	4	28	5	8	47
Platyhelminthes	0	0	11	4	6	21
Ectoparasites	8	24	39	21	18	110
Total	**22**	**47**	**132**	**52**	**47**	300

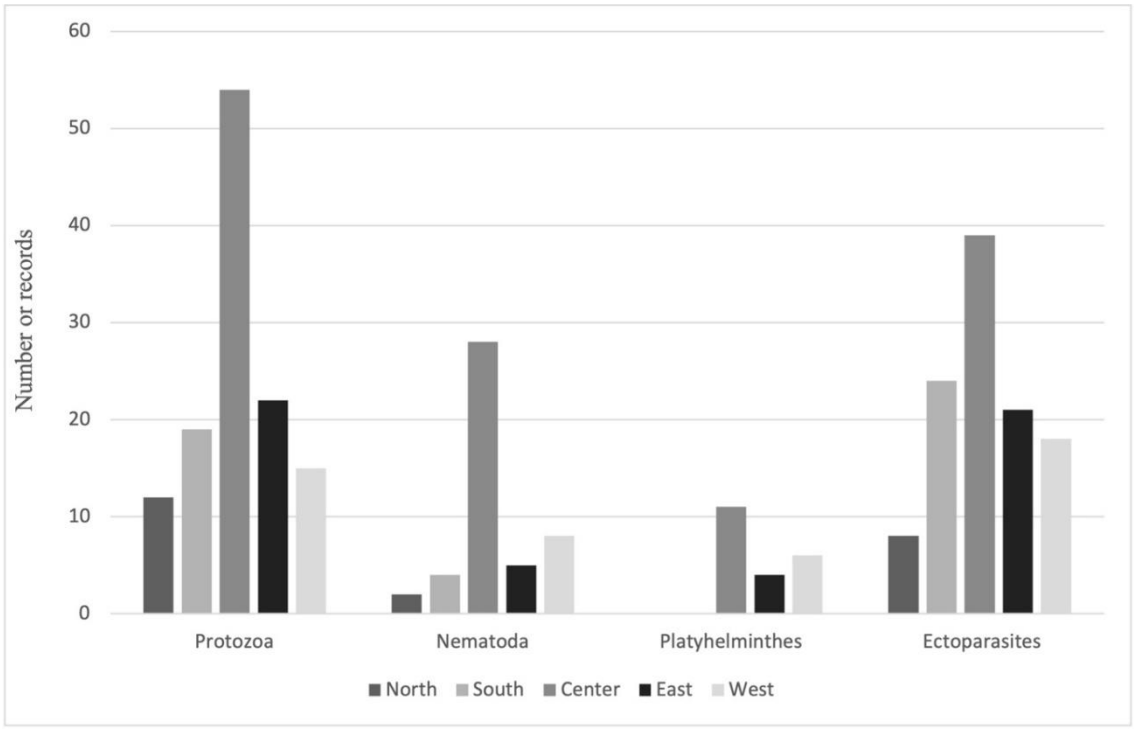

Figure 2. Number of parasites records isolated from the one-humped camel, *Camelus dromedarius* in Saudi Arabia between 1950-2021. The number of records for each group of parasites and regions are shown separately.

Table 2. Checklist of Parasites Reported form the One-Humped Camel, *Camelus dromedarius*, from Saudi Arabia Between 1950-2021

Taxa	Locality	Citation
	Protozoa	
Phylum Ciliophora		
Order Heterotrichida		
Balantidiidae		
Balantidium coli	Riyadh (Center region)	Al-Tayib (2014)
		Ismael *et al.* (2016)
		Abd Alfatah (2021)
	Makkah (West)	Ismael *et al.* (2016)
	Qassim (Center)	Abd Alfatah (2021)
	Taif (West)	Abd Alfatah (2021)
Phylum Apicomplexa		
Order Piroplasmida		
Babesiidae		
Babesia bovis	Abha (South)	Mostafa and Saad (2014)
	Khamis Mushait abattoirs (Aseer region) (South)	Mostafa and Saad (2014)
Babesia sp.	Riyadh (Center)	Ismael *et al.* (2016)
	Makkah (West)	Ismael *et al.* (2016)
Theileriidae		
Theileria sp.	Buraydah (Center)	El-Bahy *et al.* (2008)
	Al-Mezneb (Center)	El-Bahy *et al.* (2008)
	Al-Rass (Center)	El-Bahy *et al.* (2008)
	Riyadh (Center)	Ismael *et al.* (2016)
	Makkah (West)	Ismael *et al.* (2016)
Order Eucoccidiorida		
Eimeriidae		
Eimeria cameli	Unspecified locality from Saudi Arabia	Boid *et al.* (1985)
	Riyadh Region (Center)	Al-Megrin (2015b)
		Al-Megrin (2020)
		Hussein *et al.* (1987)
		Kasim *et al.* (1985)
	Jeddah (West)	Kasim *et al.* (1985)
		Hussein *et al.* (1987)

	Dammam (East)	Kasim *et al.* (1985)
		Hussein *et al.* (1987)
	Hail (North)	Kasim *et al.* (1985)
		Hussein *et al.* (1987)
	Jazan (South)	Kasim *et al.* (1985)
		Hussein *et al.* (1987)
	Modern abattoir in Unayzah (Center)	Metwally, Al-Otaibi, Albasyouni, *et al.* (2020)
	Slaughtered in West Abattoir in Riyadh (Center)	Metwally, Al-Otaibi, Albasyouni, *et al.* (2020)
Eimeria dromedarii	Riyadh (Center)	Kasim *et al.* (1985)
		Hussein *et al.* (1987)
	Jeddah (West)	Kasim *et al.* (1985)
		Hussein *et al.* (1987)
	Dammam (East)	Kasim *et al.* (1985)
		Hussein *et al.* (1987)
	Hail (North)	Kasim *et al.* (1985)
		Hussein *et al.* (1987)
	Jazan (South)	Kasim *et al.* (1985)
		Hussein *et al.* (1987)
	Qassim region (Center)	El-Bahy *et al.* (2008)
Eimeria rajasthani	Riyadh (Center)	Kasim *et al.* (1985)
		Hussein *et al.* (1987)
	Jeddah (West)	Kasim *et al.* (1985)
		Hussein *et al.* (1987)
	Dammam (East)	Kasim *et al.* (1985)
		Hussein *et al.* (1987)
	Hail (North)	Kasim *et al.* (1985)
		Hussein *et al.* (1987)
	Jazan (South)	Kasim *et al.* (1985)
		Hussein *et al.* (1987)
	Qassim region (Center)	El-Bahy *et al.* (2008)
	Modern abattoir in Unayzah (Center)	Metwally *et al.* (2020)
	Slaughtered in West Abattoir in Riyadh (Center)	Metwally *et al.* (2020)
Eimeria pellerdyi	Modern abattoir in Unayzah (Center)	Metwally *et al.* (2020)
	Slaughtered in West Abattoir in Riyadh (Center)	Metwally *et al.* (2020)
Eimeria spp.	Qassim (Center)	Abd Alfatah (2021)
	Riyadh (Center)	Abd Alfatah (2021)
	Taif (West)	Abd Alfatah (2021)
Coccidia sp.	Buraydah (Center)	El-Bahy *et al.* (2008)
	Al-Mezneb (Center)	El-Bahy *et al.* (2008)
	Al-Asiah (Center)	El-Bahy *et al.* (2008)
	Al-Rass (Center)	El-Bahy *et al.* (2008)
	Oklet Al-Sakoor (Center)	El-Bahy *et al.* (2008)
Coccidia sp.	Buraydah (Center)	El-Bahy *et al.* (2008)
	Al-Mezneb (Center)	El-Bahy *et al.* (2008)
Isospora canis	Al-Ahsa (East)	Hilali *et al.* (1995)
Isospora felis	Al-Ahsa (East)	Hilali *et al.* (1995)
Isospora rivolta	Al-Ahsa (East)	Hilali *et al.* (1995)
Sarcocystidae		
Hammondia heydorni	Al-Ahsa (East)	Hilali *et al.* (1995)
Neospora caninum	Riyadh province (Center)	Al-Anazi (2011)
	Al-Hofuf (East)	Mohammed *et al.* (2020)
	Riyadh city (Center)	Mohammed *et al.* (2020)
	Tabuk (North)	Mohammed *et al.* (2020)
	Jizan (South)	Mohammed *et al.* (2020)
	Taif (West)	Mohammed *et al.* (2020)
	Unspecific localities across all regions of Saudi Arabia (Central, Eastern, Northern, Southern, Western)	Aljumaah *et al.* (2018)
Sarcocystis cameli	Al-Ahsa (East)	Hilali et al. (1995)

	West Abattoir of in Riyadh city (Center)	Metwally *et al.* (2020)
	Dammam Slaughterhouses (East)	Metwally *et al.* (2020)
Sarcocystis camelicanis	West Abattoir of in Riyadh city (Center)	Metwally *et al.* (2020)
	Dammam Slaughterhouses (East)	Metwally *et al.* (2020)
Sarcocystis sp.	Al-Ahsa (East)	Fatani *et al.* (1996)
	Riyadh (Center)	Omer *et al.* (2017)
Toxoplusma gondii	Al-Ahsa (East)	Hilali *et al.* (1995)
	Riyadh province (Center)	Al-Anazi (2011)
		Al-Khatib (2011)
		Alanazi (2013)
	The Ibex Reserve, 150 km south of Riyadh (Center)	Osama *et al.* (2013)
	Al-Kharg (Center)	Al-Khatib (2011)
	Wady Al-Dawaser (Center)	Al-Khatib (2011)
	Darmaa (Center)	Al-Khatib (2011)
	Al-Solyel (Center)	Al-Khatib (2011)
	Rafha city (Center)	Ali *et al.* (2017)
	Al-Hofuf (East)	Mohammed *et al.* (2020)
	Riyadh city (Center)	Mohammed *et al.* (2020)
	Tabuk (North)	Mohammed *et al.* (2020)
	Jizan (South)	Mohammed *et al.* (2020)
	Taif (West)	Mohammed *et al.* (2020)
Hepatozoidae		
Hepatozoon canis	Riyadh province (Center)	Alanazi *et al.* (2020)
Order Cryptosporiidae		
Eucoccidiorida		
Cryptosporidium spp.	Riyadh Region (Center)	Al-Megrin (2015a)
		El Wathig and Faye (2016)
		Abd Alfatah, (2021)
	Qassim region (Center)	Abd Alfatah (2021)
	Taif region (West)	Abd Alfatah (2021)
Phylum Sarcomastigophora		
Order Amoebida		
Entamoebidae		
Entamoeba histolytica	Qassim region (Center)	Abd Alfatah (2021)
	Taif region (West)	Abd Alfatah (2021)
Order Diplomonadida		
Hexamitidae		
Giardia spp.	Qassim region (Center)	Abd Alfatah (2021)
	Riyadh region (Center)	Abd Alfatah (2021)
	Taif region (West)	Abd Alfatah (2021)
Order Trypanosomatida		
Trypanosomatidae		
Trypanosoma evansi	Tabouk Region (North)	Al-Khalifa *et al.* (2009)
	Jazan region (South)	Al-Khalifa *et al.* (2009)
	Eastern Region	Al-Khalifa *et al.* (2009)
		A Alanazi *et al.* (2018)
	Northern Frontiers (North)	Al-Khalifa *et al.* (2009)
		A Alanazi *et al.* (2018)
	Riyadh region (Center)	Al-Khalifa *et al.* (2009)
		A Alanazi *et al.* (2018)
		Mohammed *et al.* (2017)
		Ismael *et al.* (2016)
		Metwally *et al.* (2021)
	Dawadmi (Center)	Hussein *et al.* (1991)
	Afif (Center)	Hussein *et al.* (1991)
	Al-Kharj (Center)	Hussein *et al.* (1991)
	Hafuf (East)	Hussein *et al.* (1991)
	Abqauq (East)	Hussein *et al.* (1991)
	Al-Thuqba (East)	Hussein *et al.* (1991)
	Dammam (East)	Hussein *et al.* (1991)
	Al-Hafr (East)	Hussein *et al.* (1991)
	Arar (North)	Hussein *et al.* (1991)
	Turayf (Center)	Hussein *et al.* (1991)

Qurayat (North)	Hussein *et al.* (1991)
Najran (South)	Hussein *et al.* (1991)
Makkah (West)	Hussein *et al.* (1991)
	Ismael *et al.* (2016)
Buraydah (Center)	Hussein *et al.* (1991)
	Omer *et al.* (1998)
	Al-Qarawi *et al.* (2004)
	El-Bahy *et al.* (2008)
	Alanazi et al. (2018)
	Metwally *et al.* (2021)
Al-Mezneb (Center)	Hussein *et al.* (1991)
	Omer *et al.* (1998)
	Al-Qarawi *et al.* (2004)
	El-Bahy *et al.* (2008)
	Alanazi *et al.* (2018)
	Metwally *et al.* (2021)
Al-Asiah (Center)	Hussein *et al.* (1991)
	Omer *et al.* (1998)
	Al-Qarawi *et al.* (2004)
	El-Bahy *et al.* (2008)
	Alanazi *et al.* (2018)
	Metwally *et al.* (2021)
Al-Rass (Center)	Hussein *et al.* (1991)
	Omer *et al.* (1998)
	Al-Qarawi *et al.* (2004)
	El-Bahy *et al.* (2008)
	A Alanazi *et al.* (2018)
	Metwally *et al.* (2021)
Oklet Al-Sakoor (Center)	Hussein *et al.* (1991)
	Omer *et al.* (1998)
	Al-Qarawi *et al.* (2004)
	El-Bahy *et al.* (2008)
	Alanazi *et al.* (2018)
	Metwally *et al.* (2021)
Farasan (South)	Hussein *et al.* (1991)
	Alarabi *et al.* (2019)
	Elobaid *et al.* (2021)
Alarda (South)	Hussein *et al.* (1991)
	Alarabi *et al.* (2019)
	Elobaid *et al.* (2021)
Samtah (South)	Hussein *et al.* (1991)
	Alarabi *et al.* (2019)
	Elobaid *et al.* (2021)
Beash (South)	Hussein *et al.* (1991)
	Alarabi *et al.* (2019)
	Elobaid *et al.* (2021)
Abuareesh (South)	Hussein *et al.* (1991)
	Alarabi *et al.* (2019)
	Elobaid *et al.* (2021)
Al-Darb (South)	Hussein *et al.* (1991)
	Alarabi *et al.* (2019)
	Elobaid *et al.* (2021)
Al-Aridah (South)	Hussein *et al.* (1991)
	Alarabi *et al.* (2019)
	Elobaid *et al.* (2021)
Al-Ahad (South)	Hussein *et al.* (1991)
	Alarabi *et al.* (2019)
	Elobaid *et al.* (2021)
Al-Khobah (South)	Hussein *et al.* (1991)
	Alarabi *et al.* (2019)
	Elobaid *et al.* (2021)
Al-Jouf region (North)	El Wathig and Faye (2013)
	Elwathig *et al.* (2016)
University Veterinary Clinic, Hufof Veterinary Clinic (East)	Al-Salameen *et al.* (2016)
Hufof Slaughterhouse (East)	Al-Salameen *et al.* (2016)

	Hail (North)	Alanazi *et al.* (2018)
	Unspecific regions of Saudi Arabia (Eastern, Central, Western, Southern)	Al-Afaleq *et al.* (2015)
	Nematoda	
Phylum Nematoda		
Order Strongylida		
Molineidae		
Nematodirus spp.	Riyadh Region (Center)	Al-Megrin (2015b)
		Al-Megrin (2020)
		Abd Alfatah (2021)
	Qassim region (Center)	Haroun *et al.* (1996)
		Abd Alfatah (2021)
	Taif region (West)	Abd Alfatah (2021)
Strongylidae		
Oesophagostomum spp.	Qassim region (Center)	Haroun *et al.* (1996)
		El-Bahy *et al.* (2008)
Strongylus spp.	Riyadh Region (Center)	Abd Alfatah (2021)
	Qassim region (Center)	Abd Alfatah (2021)
	Taif region (West)	Abd Alfatah (2021)
Order Rhabditida		
Cooperiidae		
Cooperia spp.	Qassim region (Center)	Haroun *et al.* (1996)
Onchocercidae		
Dipetalonema evansi	Riyadh Region (Center)	Al-Khalifa *et al.* (2009)
	Eastern Region	Al-Khalifa *et al.* (2009)
Trichostrongylidae		
Haemonchus longistipes	Abha province (South)	Dajem *et al.* (2019)
	Riyadh (Center)	Hussein *et al.* (1987)
	Jeddah (West)	Hussein *et al.* (1987)
	Dammam (East)	Hussein *et al.* (1987)
	Hail (North)	Hussein *et al.* (1987)
	Jazan (South)	Hussein *et al.* (1987)
	Al-Ahsa (East)	Hassan *et al.* (2011)
Haemonchus spp.	Riyadh Region (Center)	Al-Megrin (2015b)
	Qassim region (Center)	Haroun *et al.* (1996)
	Eastern Province via the Veterinary Teaching Hospital, King Faisal University (East)	Alhendi (2000)
Marshallagia spp.	Riyadh Region (Center)	Abd Alfatah (2021)
	Qassim region (Center)	Abd Alfatah (2021)
	Taif region (West)	Abd Alfatah (2021)
Osrtertagia spp.	Riyadh Region (Center)	Al-Megrin (2015b)
		Al-Megrin (2020)
Trichostrongylus spp.	Riyadh Region (Center)	Al-Megrin (2015b)
		Al-Megrin (2020)
	Qassim region (Center)	Haroun *et al.* (1996)
Strongyloididae		
Strongyloides spp.	Buraydah (Center)	Haroun *et al.* (1996)
		El-Bahy *et al.* (2008)
	Al-Mezneb (Center)	Haroun *et al.* (1996)
		El-Bahy *et al.* (2008)
	Al-Asiah (Center)	Haroun *et al.* (1996)
		El-Bahy *et al.* (2008)
	Al-Rass (Center)	Haroun *et al.* (1996)
		El-Bahy *et al.* (2008)
Order Spirurida		
Filariidae		
Onchocerca fasciata	Jeddah abattoir (West)	Ghandour *et al.* (1991)
		Cheema *et al.* (1984)
	Abha (South)	Nasher (1986)
		Cheema *et al.* (1984);
	Hofuf (East)	Cheema *et al.* (1984)
	Riyadh (Center)	Cheema *et al.* (1984)
	Buraydah (Center)	Cheema *et al.* (1984)
	Hail (North)	Cheema *et al.* (1984)

	Taif (West)	Cheema *et al.* (1984)
	Makkah (West)	Cheema *et al.* (1984)
	Najran (South)	Cheema *et al.* (1984)
Order Trichocephalida		
Trichurida		
Trichuris spp.	Riyadh Region (Center)	Al-Megrin (2015b) Al-Megrin (2020) Abd Alfatah (2021)
	Buraydah (Center)	El-Bahy *et al.* (2008) Abd Alfatah (2021)
	Al-Mezneb (Center)	El-Bahy *et al.* (2008) Abd Alfatah (2021)
	Al-Asiah (Center)	El-Bahy *et al.* (2008) Abd Alfatah (2021)
	Al-Rass (Center)	El-Bahy *et al.* (2008) Abd Alfatah (2021)
	Taif (West)	Abd Alfatah (2021)
Platyhelminthes		
Phylum Platyhelminthes		
Order Cyclophyllidea		
Taeniidae		
Cysticercus bovis	Qassim Region (Center)	El-Metenawy (1999)
Cysticercus tenuicollis	Qassim Region (Center)	El-Metenawy (1999)
Cysticercus ovis	Qassim Region (Center)	El-Metenawy (1999)
Echinococcus canadensis	Abattoirs of Al Omran (Al-Ahsa, Dammam, Eastern Province) (East)	Al-Hizab *et al.* (2021)
Echinococcus granulosus	Al-Ahsa at the Veterinary Teaching Hospital of King Faisal University (East)	Elamin *et al.* (2001)
	Abattoirs of Al Omran (Al-Ahsa, Dammam, Eastern Province) (East)	Al-Hizab *et al.* (2021)
	Jeddah (West)	Bakhraibah *et al.* (2018)
	Al-Madinah Al-Munawarah (Madinah) (West)	Al-Mutairi *et al.* (2020)
Echinococcus ortleppi	abattoirs of Al Omran (Al-Ahsa, Dammam, Eastern Province) (East)	Al-Hizab *et al.* (2021)
Echinococcus sp.	Imported internationally animals from the main governmental abattoir in Jeddah Province (West)	Toulah *et al.* (2017)
	Slaughterhouses in Al-Madina AlMunawwara (Madina) (West)	Fdaladdin *et al.* (2018)
Taenia ovis	Al Kakee's Slaughter (Makkah) (West)	Bakhraibah and Alsulami (2018)
Anoplocephalidae		
Moniezia expansa	Riyadh Region (Center)	Al-Megrin (2015b) Al-Megrin (2020)
Moniezia spp.	Qassim region (Center)	Abd Alfatah (2021)
	Riyadh region (Center)	Abd Alfatah (2021)
	Taif region (West)	Abd Alfatah (2021)
Stilesia spp.	Riyadh Region (Center)	Al-Megrin (2015b) Al-Megrin (2020)
Order Echinostomida		
Fasciolidae		
Fasciola sp.	Buraydah (Center)	El-Bahy *et al.* (2008)
	Al-Mezneb (Center)	El-Bahy *et al.* (2008)
	Al-Asiah (Center)	El-Bahy *et al.* (2008)
	Al-Rass (Center)	El-Bahy *et al.* (2008)
Ectoparasites		
Phylum Arthropoda		
Order Ixodida		
Ixodidae		
Amblyomma gema	Najran (South)	Abdally (2008a)

Amblyomma variegatum	Najran (South)	Abdally (2008a)
Amblyomma sp.	Arar (North)	Abdally (2008a)
Boophilus annulatus	Hail region (North)	Al-Shammery *et al.* (2011)
Haemaphysalis sp.	Rumah (Center)	Alanazi *et al.* (2018)
Hyalomma anatolicum anatolicum	Al-Medina (West)	Al-Khalifa *et al.* (1987)
	Jazan (South)	Al-Khalifa *et al.* (1987)
	Al-Dawadimi (Center)	Al-Khalifa *et al.* (1987)
	Samtah (South)	Al-Khalifa *et al.* (1987)
	Najran (South)	Abdally (2008a)
	Rumah (Center)	Alanazi *et al.* (2018)
	Riyadh Province (Center)	Alanazi *et al.* (2019)
	Al-Ahsa (East)	Abdally *et al.* (2020)
	Kilabyiah village (10 km north west of Hofuf) (East)	Omer *et al.* (2021)
Hyalomma anatolicum excavatum	Al-Medina (West)	Al-Khalifa *et al.* (1987)
	Khiber (West)	Al-Khalifa *et al.* (1987)
	Umluj (North)	Al-Khalifa *et al.* (1987)
	Makkah (West)	Al-Khalifa *et al.* (1987)
	Al-Dawadmi (Center)	Al-Khalifa *et al.* (1987)
	Afif (Center)	Al-Khalifa *et al.* (1987)
	Khibash (Center)	Al-Khalifa *et al.* (1987)
	Jazan (South)	Al-Khalifa *et al.* (1987)
	Samtah (South)	Al-Khalifa *et al.* (1987)
	Najran (South)	Al-Khalifa *et al.* (1987) Abdally (2008a)
	Riyadh region (Center)	Alanazi *et al.* (2018)
	Al-Ahsa (East)	Abdally *et al.* (2020)
Hyalomma dromedarii	Khamis Mushait livestock market (North)	El Shoura *et al.* (1990)
	Al-Medina (West)	Al-Khalifa *et al.* (1987)
	Khiber (West)	Al-Khalifa *et al.* (1987)
	Umluj (North)	Al-Khalifa *et al.* (1987)
	Makkah (West)	Al-Khalifa *et al.* (1987)
	Khibash (Center)	Al-Khalifa *et al.* (1987)
	Jazan (South)	Al-Khalifa *et al.* (1987)
	Al-Darb (South)	Al-Khalifa *et al.* (1987)
	Sabia (South)	Al-Khalifa *et al.* (1987)
	Samtah (South)	Al-Khalifa *et al.* (1987)
	Taif (West)	Al-Khalifa *et al.* (1987) Albogami (2020)
	Afif (Center)	Al-Khalifa *et al.* (1987) Elbir *et al.* (2020)
	Najran (South)	Al-Khalifa *et al.* (1987) Abdally (2008a)
	Kilaakh (50 km from Taif) (West)	Charrel *et al.* (2007)
	Riyadh province (Center)	Diab *et al.* (2006) Al-Shammery *et al.* (2011) Alanazi *et al.* (2018) Alajmi *et al.* (2019) Alanazi *et al.* (2019)
	Al-Dawadimi (Center)	Al-Khalifa *et al.* (1987) Alanazi *et al.* (2018)
	Al-Majmaah (Center)	Alanazi *et al.* (2018)
	Rumah (Center)	Alanazi *et al.* (2018)
	Al-Kharj (Center)	Alanazi *et al.* (2018)
	Jubail city (East)	Fallatah *et al.* (2019)
	Al-Ahsa (East)	Abdally *et al.* (2020) Elbir *et al.* (2020) Hemida *et al.* (2021);
	Riyadh city (Center)	Alanazi *et al.* (2018) Elbir *et al.* (2020)
	Hofuf (East)	Elbir *et al.* (2020)
	Al-Gharbia (East)	Elbir *et al.* (2020)

	Uqair (East)	Elbir *et al.* (2020)
	Khurais (Center)	Elbir *et al.* (2020)
	Arar (North)	Elbir *et al.* (2020)
	Dammam (East)	Elbir *et al.* (2020)
	Buraidah (Center)	Elbir *et al.* (2020)
	Asir (South)	Elbir *et al.* (2020)
	Kilabyiah village (10 km north west of Hofuf) (East)	Omer *et al.* (2021)
	Alkhurma district (in Jeddah region) (West)	Zakham *et al.* (2021)
	Taif city (West)	Zakham *et al.* (2021)
Hyalomma excavatum	Riyadh region (Center)	A Alanazi *et al.* (2018)
		Alanazi *et al.* (2019)
		Alanazi *et al.* (2020)
Hyalomma impeltatum	Al-Medina (West)	Al-Khalifa *et al.* (1987)
	Khiber (West)	Al-Khalifa *et al.* (1987)
	Umluj (North)	Al-Khalifa *et al.* (1987)
	Makkah (West)	Al-Khalifa *et al.* (1987)
	Taif (West)	Al-Khalifa *et al.* (1987)
	Khibash (Center)	Al-Khalifa *et al.* (1987)
	Jazan (South)	Al-Khalifa *et al.* (1987)
	Al-Darb (South)	Al-Khalifa *et al.* (1987)
	Sabia (South)	Al-Khalifa *et al.* (1987)
	Samtah (South)	Al-Khalifa *et al.* (1987)
	Afif (Center)	Al-Khalifa *et al.* (1987)
		Elbir *et al.* (2020)
	Najran (South)	Al-Khalifa *et al.* (1987)
		Abdally (2008a)
	Al-Dawadimi (Center)	Al-Khalifa *et al.* (1987)
		Alanazi *et al.* (2018)
	Al-Majmaah (Center)	Alanazi *et al.* (2018)
	Rumah (Center)	Alanazi et al. (2018)
	Riyadh city (Center)	Alanazi *et al.* (2018)
	Al-Kharj (Center)	Alanazi *et al.* (2018)
	Riyadh region (Center)	Alanazi *et al.* (2018)
		Alanazi *et al.* (2019)
		Alanazi *et al.* (2020)
	Al-Ahsa (East)	Abdally *et al.* (2020)
Hyalomma schulzei	Najran (South)	Abdally (2008a)
	Riyadh region (Center)	Alanazi *et al.* (2018)
		Alanazi *et al.* (2019)
	Al-Ahsa (East)	Abdally *et al.* (2020)
Hyalomma marginatum rufipes	Sabia (South)	Al-Khalifa *et al.* (1987)
	Najran (South)	Al-Khalifa *et al.* (1987)
		Abdally (2008a)
	Riyadh region (Center)	Alajmi *et al.* (2019)
	Al-Ahsa (East)	Abdally *et al.* (2020)
Hyalomma marginatum turanicum	Al-Ahsa (East)	Abdally *et al.* (2020)
Hyalomma truncatum	Sabia (South)	Al-Khalifa *et al.* (1987)
	Najran (South)	Al-Khalifa *et al.* (1987)
		Abdally (2008a)
	Riyadh region (Center)	Alanazi *et al.* (2018)
		Alanazi *et al.* (2019)
Hyalomma spp.	Arar (North)	Abdally (2008b)
	Northeast and Southeast Jeddah (West)	Charrel *et al.* (2007)
	Riyadh (Center)	Elbir *et al.* (2020)
Rhipicephalus evertsi	Riyadh province (Center)	Alanazi *et al.* (2019)
Rhipicephalus camicasi	Riyadh province (Center)	Alanazi *et al.* (2018)
		Alanazi *et al.* (2019)
Rhipicephalus praetextatus	Al-Ahsa (East)	Abdally *et al.* (2020)
Rhipicephalus sanguineus	Riyadh province (Center)	Diab *et al.* (2006)
		Alanazi *et al.* (2018)
		Alanazi *et al.* (2019)
Rhipicephalus turanicus	Riyadh province (Center)	Diab *et al.* (2006)

		Alanazi *et al.* (2018)
		Alanazi *et al.* (2019)
	Al-Dawadimi (Center)	Alanazi *et al.* (2018)
	Rumah (Center)	Alanazi *et al.* (2018)
	Al-Ahsa (East)	Abdally *et al.* (2020)
Argasidae		
Ornithodoros savignyi	Northeast and Southeast Jeddah (West)	Charrel *et al.* (2007)
Cephalopina titillator	Riyadh Region (Center)	Hussein *et al.* (1983)
		Hussein *et al.* (1982)
		Alahmed (2002)
	Jeddah (West)	Hussein *et al.* (1982)
	Al-Ahsa region (East)	Abdally (2008c)
Order Diptera		
Oestridae		
Oestrus ovis	Riyadh abattoir (Center)	Alahmed (2002)
	Al-Ahsa region (East)	Abdally (2008c)
Calliphoridae		
Chrysomya bezziana	Al-Ahsa region (East)	Abdally (2008c)
Lucilia sericata	Al-Ahsa region (East)	Abdally (2008c)
Sarcophagidae		
Sarcophaga cruentata	Al-Ahsa region (East)	Abdally (2008c)

Table 2 offers an overview of all records of parasites infecting the one-humped camel, *C. dromedarius*, in Saudi Arabia from previous studies between 1950-2021 associated with the region. In the Protozoa records, the highest number of records belong to the Center region of Saudi Arabia (54 records) followed by the East part of the country (22). The North region and West regions received the lowest records 12 and 15, respectively. The majority of the protozoan records belong to the Phylum Apicomplexa, from genera such as *Babesia*, *Theileria*, *Coccidia*, *Eimeria*, *Isospora*, *Hammondia*, *Neospora*, *Sarcocystis*, *Toxoplasma*, *Hepatozoon*, *Cryptosporidium*, *Entamoeba*, *Trypanosoma*, and *Giardia*. The remaining records belong to the Phylum Ciliophora and *Balantidium coli* (Table 1).

Platyhelminthes have no published records in the North and South regions of Saudi Arabia between 1950-2021, while Nematoda only 2 and 4 records, respectively (Table 1). The center region received more attention where there are 28 records of Nematoda compared to 11 records for Platyhelminthes because of the capital city, Riyadh. The East and West regions of Saudi Arabia have lower records of parasites.

The highest records of ectoparasites are high in the Center part of the country (39 records) compared to 8 records from the North region. Both, the South and East region received a parallel number of records 24 and 21, respectively. The majority of ectoparasites belong to the order Ixodida, while the remaining belong to parasitic behavior species belonging to the order Diptera.

The parasites record for one-humped camel, *Camelus dromedarius*, were 122 of Protozoa, 47 of Nematoda, 21 of Platyhelminthes, and 110 of ectoparasites. The Center region of Saudi Arabia received more attention with 132 records compared to 52 from the East, 47 from the West and South, and 22 from the North. A possible explanation of concentrations on Protozoa records might be that they are medically important to human.

The present checklist was organized taxonomically in which consist of 75 species representing 4 groups of parasites. The first group is Protozoa with 24 species. Secondly, 13 species of nematodes were reported while there were 12 species of Platyhelminthes. The last group belongs to the Arthropoda which consists of 26 reported species, most of which belong to Ixodida.

Unfortunately, 83% (10 species) of reported names of nematodes were identified into the genus level only compared to 33% (4 species) for Platyhelminthes, 29% (7 species) for Protozoa, and 11% (3 species) for ectoparasites. A possible explanation for the low number of identified nematodes into the species level may be the lack of taxonomists in Saudi Arabia and the morphological characters of nematodes were almost similar. It led to the lack of facilities to distinguish into species level. Most of the available parasitologists are dealing with parasites that are important to human health, animal production, and agriculture fields since these are the main focuses of Saudi Arabia Vision 2030.

Another issue that emerges from these finding was the limited sampling of parasites infecting camels from the North part of Saudi Arabia. The findings reported here suggest that there were no official published records for the Platyhelminthes or a limited number of records for Nematoda (Table 1) (Figure 2). This region was important because it connects Saudi Arabia to other continents of Asia, Africa, and Europe. Possibly, there were many records of Platyhelminthes that could be missing from one-humped camels from North region of Saudi Arabia because of the occurrence of tapeworms from camels in the countries located in the North of Saudi Arabia. For example, *E. granulosus* was recorded from camels in Jordan (Issa *et al.* 2018). Since there are limited geographical barriers between Saudi Arabia, Iraq, and Jordan, it can therefore be assumed that there was a high chance for the occurrence of

Platyhelminthes in the North camels of Saudi Arabia as well.

Subsequently, the present results illustrate that some of the localities were unspecific in the locality of sampling. They refer the locality of sampling into large regions or megacities such as Riyadh and Makkah. For example, the size of Riyadh city is approximately 1970 km^2, and it increases by the time. Specifying the sampling locality is important to understand the biodiversity and distribution of parasites within these cities.

CONCLUSION

This study encourages parasitologists to increase their effort in sampling of *C. dromedarius* from diverse regions of Saudi Arabia, especially from the North side. These research findings were providing data and important to understand the biodiversity and evolution of parasites in the Palearctic realm. Further research should be undertaken to investigate and use the molecular approach to support the clear identification of the species that belong to Platyhelminthes and Nematoda from Saudi Arabia.

The findings reported here shed new light for taxonomists to investigate the morphological variabilities that can lead to describe new species from Saudi Arabia. The contribution of this study has been to understand the current gaps in the distribution and biodiversity of parasites infecting the dromedary camel in Saudi Arabia.

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