



Vertebrate Pest Outbreaks in Gaza Displacement Camps under Conditions of Israeli War of Genocide and Ethnic Cleansing (2023–2026): Ecological Drivers, Public Health Risks, and Humanitarian impacts

Abdel Fattah N. Abd Rabou^{*1}, Mahmoud I. Elhabiby², Maha F. Gafar², Yara M. Alfera¹, Mahmoud W. El-Hindi¹, Yousif K. Ibrahim³, Mazen S. Al-Banna³, Rana H. Idais³, Azhar A. Tanboura⁴, Tamer M. Alsalibi⁵, Abdel Fattah A. Qaraman⁶, Mohammed R. Al-Agha⁷, Mohammed A. Abd Rabou⁷, Ayman W. Dardona⁸, Saud S. Shawa⁹, Ola A. Abd Rabou¹⁰, Bassam A. Tayeh¹¹, Fahid K. Rabah¹¹, Mazen T. Abualtayef¹¹, Asmaa A. Abd Rabou¹¹, and Maged M. Yassin¹²

¹Department of Biology and Biotechnology, Faculty of Science, Islamic University of Gaza, P.O.Box 108, Gaza Strip, Palestine

²Department of Medical Laboratory Sciences, Faculty of Medical Sciences, Al-Aqsa University, Gaza Strip, Palestine

³Water & Environment Quality Authority, Gaza Strip, Palestine

⁴Department of Public Awareness, Municipality of Beit Lahia, North Gaza Governorate, Gaza Strip, Palestine

⁵General Director of Beit Lahia Municipality, North Gaza Governorate, Gaza Strip, Palestine

⁶Dean of Scientific Research and Libraries, Israa University, Gaza Strip, Palestine

⁷Department of Environment & Earth Sciences, Faculty of Science, Islamic University of Gaza, Gaza Strip, Palestine

⁸Department of Pharmacy and Biotechnology, Faculty of Pharmacy, University of Palestine, Gaza Strip, Palestine

⁹Director of VETCO Veterinary Services Center, Gaza City, Gaza Strip, Palestine

¹⁰Department of Smart Systems Engineering, Faculty of Engineering, Islamic University of Gaza, Gaza Strip, Palestine

¹¹Department of Civil Engineering, Faculty of Engineering, Islamic University of Gaza, Gaza Strip, Palestine

¹²Faculty of Medicine, Islamic University of Gaza, Gaza Strip, Palestine

ABSTRACT

The ongoing Israeli war of genocide and ethnic cleansing (2023–2026) in the Gaza Strip has caused severe environmental degradation, transforming urban ecosystems and creating favorable conditions for vertebrate pest proliferation in displacement camps. This review integrates scientific literature, humanitarian reports, and field observations to assess vertebrate pest diversity, ecological drivers, public health significance, and management priorities in war-affected settings. The study identifies a diverse assemblage of synanthropic vertebrates, including commensal rodents, free-ranging dogs, feral cats, scavenging birds, reptiles, and amphibians, adapted to collapsed sanitation systems, waste accumulation, sewage leakage, rubble, and infrastructure destruction. Rodents, particularly the Norway Rat (*Rattus norvegicus* Berkenhout, 1769), Black Rat (*Rattus rattus* Linnaeus, 1758), and House Mouse (*Mus musculus* Linnaeus, 1758), represent the most abundant and epidemiologically significant pests due to their contamination of food and water, damage to humanitarian supplies, and role as reservoirs of zoonotic pathogens. Venomous snakes, especially the Palestine Viper (*Daboia palaestinae* Werner, 1938), pose serious medical risks under limited healthcare access, while free-ranging dogs (*Canis familiaris* Linnaeus, 1758) increase bite and zoonotic disease risks, and Feral Cats (*Felis catus* Linnaeus, 1758) contribute to *Toxoplasma gondii* transmission, ectoparasites, and food contamination. Scavenging birds may facilitate mechanical pathogen transport, whereas amphibians primarily serve as indicators of environmental deterioration. Vertebrate pest proliferation reflects the broader collapse of sanitation, waste management, and public health systems caused by war-related environmental disruption. Effective mitigation requires integrated pest management focused on environmental restoration, improved sanitation, ecological monitoring, targeted control measures, and community participation to reduce health risks and support humanitarian recovery in the Gaza Strip.

Keywords: Displacement camps; vertebrate pests; rodents; free-ranging dogs; feral cats; scavenging birds; reptiles; environmental degradation; war ecology; zoonotic diseases; humanitarian crisis; integrated pest management; Gaza Strip; Palestine. Milak River, Primary productivity, ecosystem health, Light and dark bottles.

Citation: Abdel Fattah N. Abd Rabou, Mahmoud I. Elhabiby, Maha F. Gafar, Yara M. Alfera, Mahmoud W. El-Hindi, Yousif K. Ibrahim, Mazen S. Al-Banna, Rana H. Idais, Azhar A. Tanboura, Tamer M. Alsalibi, Abdel Fattah A. Qaraman, Mohammed R. Al-Agha, Mohammed A. Abd Rabou, Ayman W. Dardona, Saud S. Shawa, Ola A. Abd Rabou, Bassam A. Tayeh, Fahid K. Rabah, Mazen T. Abualtayef, Asmaa A. Abd Rabou, and Maged M. Yassin [2026]. Vertebrate Pest Outbreaks in Gaza Displacement Camps under Conditions of Israeli War of Genocide and Ethnic Cleansing (2023–2026): Ecological Drivers, Public Health Risks, and Humanitarian impacts. *Journal of Diversity Studies*. DOI: <https://doi.org/10.51470/JOD.2026.5.2.05>

Corresponding Author: Abdel Fattah N. Abd Rabou

E-mail Address: arabou@iugaza.edu.ps

Article History: Received 06 April 2026 | Revised 03 May 2026 | Accepted 09 June 2026 | Available Online July 04, 2026

Copyright: © 2026 by the author. The license of Journal of Diversity Studies. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. INTRODUCTION

Since the onset of the ongoing Israeli war of genocide and ethnic cleansing (2023–2026) in October 2023, the Gaza Strip has been experiencing an unprecedented humanitarian and environmental catastrophe. Intensive military operations have caused widespread destruction of residential neighborhoods, hospitals, schools, agricultural areas, and essential infrastructure, while also severely disrupting water supply systems, sanitation services, wastewater treatment facilities, electricity networks, and municipal solid waste management [1] [2]. Alongside these recent impacts, chronic environmental management deficiencies have long contributed to persistent weaknesses in waste disposal and sanitation infrastructure, which have been identified as major drivers of environmental degradation in the region [3].

As a result, most of the population has been displaced into overcrowded shelters and makeshift tent camps, where access to safe drinking water, adequate sanitation, healthcare, and basic environmental services remains extremely limited [4]. Environmental assessments conducted in northern Gaza have previously highlighted the significant ecological and public health consequences of wastewater treatment failures, particularly in relation to the Beit Lahia wastewater treatment plant and its surrounding environment, emphasizing the long-standing vulnerability of sanitation infrastructure in the Gaza Strip [5].

These compounded conditions have produced a severe public health emergency characterized by heightened risks of infectious disease outbreaks driven by overcrowding, environmental contamination, and systemic collapse of health services [6]. At the same time, the accumulation of millions of tons of rubble, unmanaged solid waste, stagnant wastewater, and decomposing organic material has fundamentally transformed urban ecosystems, creating highly disturbed environments that favor opportunistic wildlife and increase human exposure to vertebrate pests (Figure 1) [7]–[12].

Ecological studies in Wadi Gaza Nature Reserve have highlighted the importance of wetland ecosystems in maintaining ecological balance, supporting biodiversity, and providing essential environmental services in the Gaza Strip [13,14]. Environmental conditions within these peri-urban wetlands have also been shown to influence vector abundance, pest ecology, and community awareness of pest control [15]. Furthermore, vegetation structure and composition increase habitat complexity, supporting diverse organisms, including disease vectors and vertebrate pests [16]. These findings underscore the importance of conserving natural habitats and improving environmental management to reduce pest proliferation and enhance ecosystem resilience.



Figure 1: Rubble and collapsed buildings resulting from the ongoing Israeli War of Genocide and Ethnic Cleansing (2023–2026) in the Gaza Strip provide ideal refuges for rodents, reptiles, and other pest species.

Large-scale environmental disturbance profoundly alters wildlife communities by modifying habitats, resource availability, and species interactions [17]–[19]. In humanitarian emergencies, deteriorating sanitation, interrupted waste collection, food waste accumulation, and abandoned infrastructure provide abundant food, shelter, and breeding sites for synanthropic vertebrates [20]. Consequently, displacement camps frequently become ecological hotspots where rodents, free-ranging dogs, feral cats, scavenging birds, and several reptile species thrive in proximity to humans (Personal Observations).

The vertebrate fauna of the Gaza Strip encompasses a rich diversity of mammals, birds, reptiles, and amphibians inhabiting coastal, agricultural, urban, and semi-natural ecosystems [21]–[26]. Previous records have confirmed the occurrence of several wild carnivore species in the Gaza Strip, reflecting their historical presence in both natural and peri-urban habitats before recent large-scale environmental disturbances [27]. This biodiversity is further reflected in semi-natural ecosystems such as Al-Mawasi, which support a wide range of mammalian, reptilian, and amphibian species, underscoring the ecological richness of remaining habitats despite increasing anthropogenic pressure [28]. In addition, components of this fauna are maintained under ex-situ conditions in zoological gardens in the Gaza Strip, where avian and mammalian species represent a subset of regional biodiversity and reflect human-mediated wildlife management practices in urban environments [29] [30].

While most species contribute to ecosystem functioning, a limited number are highly adaptable to human-modified environments and may become pests when ecological conditions favor rapid population growth. The terrestrial vertebrate diversity of Palestine has been systematically documented through biological collections and university exhibitions in the Gaza Strip, which preserve representative specimens of the regional fauna and provide an important reference for understanding species composition and ecological distribution [31]. In addition, museum collections of mummified marine and terrestrial vertebrates offer a valuable pre-war ecological baseline, documenting biodiversity conditions before the Israeli military escalation in October 2023 and highlighting the historical richness of the region's fauna [32]. This baseline further underscores the ecological richness of the region despite long-standing anthropogenic pressures and environmental degradation.

Among the most prominent synanthropic species are the Norway Rat (*Rattus norvegicus* Berkenhout, 1769), the Black Rat (*Rattus rattus* Linnaeus, 1758), and the House Mouse (*Mus musculus* Linnaeus, 1758), which are considered the principal commensal rodents worldwide due to their high reproductive capacity, omnivorous diet, close association with human settlements, and well-established role as reservoirs of numerous zoonotic pathogens [33]–[37]. However, vertebrate pest problems in humanitarian settings extend beyond rodents to include free-ranging dogs, feral cats, scavenging birds, and reptiles that increasingly exploit displaced human populations and altered urban ecosystems.

Environmental deterioration across the Gaza Strip has intensified these ecological processes. Collapsed buildings and extensive rubble resulting from the ongoing Israeli war of genocide and ethnic cleansing (2023–2026) (see Figure 1) provide ideal refuges for rodents and reptiles, while damaged sewage systems, stagnant wastewater, accumulated refuse,

food waste, and animal carcasses create abundant food resources that promote their proliferation. At the same time, the severe disruption of municipal pest-control and environmental health services has facilitated the rapid expansion of vertebrate pest populations throughout urban areas and displacement camps [4] [38].

Recent humanitarian reports and field observations indicate widespread rodent infestations in displacement camps, where rats contaminate food and drinking water, damage tents and humanitarian supplies, destroy personal belongings, and occasionally bite sleeping children [39]-[42]. Similar increases have been observed in free-ranging dogs and feral cats attracted by refuse and decomposing organic matter, while scavenging birds congregate around temporary dumping sites and destroyed urban landscapes, increasing opportunities for environmental contamination and pathogen circulation [43] [44].

Vertebrate pests represent an important public-health concern because they serve as reservoirs or carriers of numerous zoonotic pathogens. Commensal rodents are associated with diseases such as leptospirosis, salmonellosis, hantavirus infections, murine typhus, rat-bite fever, and toxoplasmosis through contaminated food and water, urine, feces, bites, and ectoparasites [33] [34] [45]. In overcrowded displacement camps, where sanitation is poor, food insecurity is widespread, and healthcare services are severely constrained, these risks are substantially amplified [46]. Beyond disease transmission, vertebrate pests damage shelters, contaminate humanitarian supplies, and contribute to fear, anxiety, and reduced quality of life among displaced populations.

Reptiles have also become increasingly associated with Gaza's war-affected landscapes. Extensive rubble, abandoned buildings, and unmanaged vegetation provide suitable habitats for snakes, geckos, skinks, agamid lizards, and the Desert Monitor (*Varanus griseus* Daudin, 1803) [47] [48]. Although most reptile species contribute to natural pest regulation by preying on rodents and insects, their frequent occurrence within displacement camps increases human-wildlife encounters. Particular concern surrounds the Palestine Viper (*Daboia palaestinae* Werner, 1938), whose venomous bites constitute a medical emergency, especially where access to emergency healthcare and antivenom is limited [47] [49] [50]. Even non-venomous reptiles often generate considerable fear and psychological distress among camp residents, particularly children.

The environmental conditions prevailing in displacement camps have likewise promoted the proliferation of medically important arthropods, including mosquitoes, flies, cockroaches, fleas, lice, ticks, mites, and bed bugs. These pests contribute to disease transmission, food contamination, skin disorders, allergic reactions, and psychological discomfort [4] [51]-[56]. Fleas are particularly important in such environments because they act as vectors of several zoonotic pathogens and are closely associated with rodent infestations, which are highly prevalent in displacement camps [57]. Mosquito-borne diseases represent a major public health concern in such settings, particularly affecting vulnerable populations such as children living in overcrowded and unsanitary environments [58]. However, because their ecology and management differ fundamentally from those of vertebrate pests, they are addressed only briefly in this review.

The convergence of environmental degradation, wildlife adaptation, and human vulnerability highlights the interdependence of human, animal, and environmental health [59]. Despite increasing attention to Gaza's environmental and public-health challenges, relatively little research has examined the diversity, ecology, and impacts of vertebrate pests beyond commensal rodents. In particular, the roles of free-ranging dogs, feral cats, scavenging birds, and reptiles in displacement settings remain poorly documented.

Therefore, this review synthesizes current scientific literature, humanitarian reports, and field observations on vertebrate pests associated with displacement camps throughout the Gaza Strip. It examines the environmental drivers of pest proliferation, reviews the principal vertebrate pest species, evaluates their ecological, veterinary, and public-health significance, and discusses integrated management strategies. By bringing together evidence from ecology, zoology, environmental science, veterinary medicine, and public health, this review provides a comprehensive assessment of an underrecognized consequence of the ongoing war and identifies priorities for future research, humanitarian response, and environmental recovery.

2. METHODOLOGY

2.1. Study Area

The Gaza Strip is a narrow Mediterranean coastal enclave in southwestern Palestine, extending for approximately 42 km along the southeastern Mediterranean coast and covering about 365 km² (Figure 2). It is bordered by the Mediterranean Sea to the west, the Palestinian territories occupied by Israel since 1948 to the north and east, and Egypt to the southwest at Rafah. The territory consists primarily of a low-lying coastal plain characterized by sandy dunes, agricultural lands, urban areas, and the Wadi Gaza wetland, with elevations generally not exceeding 105 m above sea level. Home to more than 2.4 million inhabitants, the Gaza Strip is among the most densely populated regions in the world.

Since October 7, 2023, the ongoing Israeli war of genocide and ethnic cleansing (2023–2026) has caused extensive destruction of residential neighborhoods, public infrastructure, and essential services, including water supply, sanitation, sewage, and solid waste management. The resulting environmental degradation, characterized by the accumulation of millions of tons of rubble, widespread habitat destruction, sewage leakage, unmanaged solid waste, and the collapse of municipal services, has profoundly transformed urban and peri-urban ecosystems. These conditions have created highly favorable habitats for vertebrate pest proliferation, particularly within densely populated displacement camps and surrounding devastated areas [38] [60].



Figure 2: Map of Palestine showing the location of the Gaza Strip along the southeastern Mediterranean coast.

2.2 Displacement Camps

Displacement camps in the Gaza Strip are informal and rapidly formed settlements located in school yards, open urban spaces, coastal areas, agricultural margins, and partially destroyed neighborhoods. These sites are characterized by porous environments, extreme overcrowding, poor sanitation, absence of solid waste management, and damaged sewage systems, leading to stagnant wastewater and uncontrolled refuse accumulation (Figure 3). The proximity of shelters to rubble and destroyed infrastructure further worsens environmental conditions. Such settings create highly suitable habitats for vertebrate pests, including rodents, free-ranging dogs, feral cats, scavenging birds, and reptiles, increasing human–pest interactions and associated public health risks.



Figure 3: Representative displacement camps in the Gaza Strip showing widespread environmental degradation, poor sanitation, and humanitarian conditions conducive to the proliferation of medically and environmentally important vertebrate and invertebrate pests

2.3 Data Collection

This study combines a narrative literature review with field observations conducted across the Gaza Strip before and during the ongoing war. Observations focused on vertebrate pest occurrence, habitat conditions, and environmental drivers of pest proliferation, particularly within displacement camps. Qualitative data were obtained through informal interviews with displaced residents regarding pest encounters, health concerns, and daily living conditions.

2.4 Species Identification and Photographic Documentation

Species identification was based on direct field observations supported by standard taxonomic references and the author's expertise in the vertebrate fauna of the Gaza Strip.

Photographic documentation was collected during field visits to displacement camps and affected areas when security conditions allowed, supplemented by archival images. Identifications were verified using morphological and ecological criteria. Representative images illustrate species occurrence and habitat conditions in war-affected environments.

3. RESULTS

3.1. Environmental Degradation in Gaza Displacement Camps and Vertebrate Pest Proliferation

The ongoing Israeli war of genocide and ethnic cleansing (2023–2026) has caused severe environmental degradation across the Gaza Strip, fundamentally altering urban ecosystems and creating highly suitable conditions for vertebrate pest proliferation. Extensive destruction of residential areas, infrastructure, and public services has generated enormous quantities of debris and rubble—currently estimated at more than 68 million tonnes according to multiple sources—along with collapsed buildings and unmanaged open spaces. These conditions provide ideal shelter, nesting sites, and movement corridors for rodents, snakes, lizards, and other synanthropic vertebrates. The widespread accumulation of rubble, abandoned buildings, rock piles, and construction debris has particularly favored the dispersal and persistence of medically important snakes, including venomous species, as well as nuisance lizards and geckos that readily exploit cracks, crevices, and temporary shelters around displacement camps. In parallel, the collapse of solid waste management systems, wastewater treatment, and sanitation services has led to the widespread accumulation of household waste, organic refuse, animal carcasses, and stagnant sewage within displacement camps.

These conditions have significantly increased food availability and breeding opportunities while reducing environmental hygiene and pest control capacity. Elevated rodent populations have also provided abundant prey for predatory snakes, indirectly promoting their occurrence near human settlements. Field observations consistently demonstrated strong associations between pest occurrences and degraded environmental conditions. Refuse piles around tents and shelters attracted rats, stray dogs, feral cats (Figure 4), and scavenging birds, while damaged drainage systems and sewage overflow created humid microhabitats supporting both vertebrate and invertebrate pests. Rubble, collapsed structures, and accumulated construction debris further provided secure nesting, refuge, thermoregulatory, and ambush sites for rodents, snakes, lizards, and other vertebrate pests, facilitating their persistence within densely populated displacement camps and increasing the frequency of human–wildlife encounters.



Figure 4: AI-generated illustration depicting the accumulation of refuse piles around tents in displacement camps and their role in attracting commensal rodents (rats), stray dogs, and feral cats, which may pose health and safety risks to displaced populations in the Gaza Strip

3.2. Diversity and Distribution of Vertebrate Pests in Displacement Camps

Displacement camps across the Gaza Strip support a diverse assemblage of vertebrate pests that have successfully adapted to the extreme environmental conditions created by war. Extensive destruction of urban infrastructure, accumulation of solid waste, sewage leakage, and the collapse of environmental sanitation have favored the proliferation of opportunistic synanthropic species while reducing populations of more sensitive native wildlife. Field observations documented a diverse vertebrate pest community comprising mammals, birds, reptiles, and amphibians that have become closely associated with camp environments and pose varying environmental, economic, and public health concerns.

3.2.1. Mammalian Pests

Mammalian pests represented the most diverse and ecologically significant vertebrate group recorded in displacement camps across the Gaza Strip, encompassing a spectrum of commensal rodents, synanthropic domestic animals, and opportunistic wild carnivores that have increasingly exploited the heavily altered camp environments (Table 1). The proliferation of this group is closely linked to the collapse of sanitation systems, continuous accumulation of solid waste, widespread sewage leakage, and the extensive availability of anthropogenic food resources within and around displacement settings (see Figure 4).



Figure 5: Massive rodent infestations in displacement camps and destroyed neighborhoods across the Gaza Strip pose a severe public health threat. Rodents damage tents, contaminate food supplies, and have reportedly bitten displaced people, including sleeping children, increasing the risk of rodent-borne diseases: (A) Norway Rat (*Rattus norvegicus* Berkenhout, 1769); (B) A rat (*Rattus* spp.) trapped inside one of the tents housing internally displaced persons in Deir al-Balah, central Gaza Strip; and (C) Newly born House Mice (*Mus musculus* Linnaeus, 1758) in Deir al-Balah, central Gaza Strip.

Rodents constituted the most dominant and consistently observed mammalian pests, both in terms of abundance and spatial distribution. The Norway Rat (*Rattus norvegicus* Berkenhout, 1769), Black Rat (*Rattus rattus* Linnaeus, 1758), and House Mouse (*Mus musculus* Linnaeus, 1758) were recorded across nearly all surveyed camps, with particularly high densities in areas characterized by unmanaged refuse piles, damaged drainage networks, and collapsed or partially destroyed buildings (Figure 5). These species were frequently observed in close association with human habitation structures, including inside tents, temporary shelters, food storage units, humanitarian aid warehouses, and sewage-contaminated channels.

Their nocturnal activity patterns were consistently reported by residents, who described repeated incidents of food contamination, gnawing damage to stored supplies, and direct intrusions into living spaces. The ecological success of these rodents reflects their high reproductive capacity, omnivorous feeding behavior, and exceptional adaptability to unstable and resource-fluctuating environments.

Free-ranging domestic carnivores, particularly the Domestic Dog (*Canis familiaris* Linnaeus, 1758) (Figure 6) and Domestic or Feral Cat (*Felis catus* Linnaeus, 1758) (Figure 7), were widely distributed throughout displacement camps and adjacent urban ruins. Dogs were commonly observed in groups or as solitary individuals around food distribution centers, slaughter points, refuse accumulation sites, and camp entrances, where they relied heavily on discarded humanitarian aid materials and organic waste. Their presence was frequently associated with human-animal conflict events, including aggressive behavior toward children and concerns regarding potential bite injuries and zoonotic disease transmission. In contrast, feral and semi-feral cats were primarily associated with rodent-infested zones, food waste disposal sites, and densely populated tent clusters. While cats may contribute to partial suppression of rodent populations through predation, their close contact with food preparation areas raises additional public health concerns, particularly in relation to parasitic infections such as toxoplasmosis caused by *Toxoplasma gondii* (Nicolle & Manceaux, 1908), as well as ectoparasite transmission.



Figure 6: Free-ranging Domestic Dogs (*Canis familiaris* Linnaeus, 1758) are commonly observed in groups or as solitary individuals throughout displacement camps and adjacent urban ruins in the Gaza Strip



Figure 7: Dirty Domestic or Feral cats (*Felis catus* Linnaeus, 1758) are common in displacement camps in the Gaza Strip and may raise public health concerns, particularly in relation to parasitic infections

Wild carnivores were infrequently encountered; however, they were repeatedly reported by displaced residents, particularly in camps situated near agricultural lands, orchards, and heavily degraded peri-urban fringes, predominantly in the eastern parts of the Gaza Strip. These included the Red Fox (*Vulpes vulpes* Linnaeus, 1758) (Figure 8), Golden Jackal (*Canis aureus* Linnaeus, 1758), and Egyptian Mongoose (*Herpestes ichneumon* Linnaeus, 1758). The Egyptian Mongoose is a highly adaptable carnivore capable of occupying a range of human-modified and peri-urban habitats in the Gaza Strip. Although direct observations were limited, interview data suggest intermittent incursions into camp peripheries, likely driven by habitat destruction, reduced prey availability in natural areas, and increased foraging opportunities in waste-rich environments. Residents expressed particular concern regarding potential predation on small livestock such as chickens and ducks maintained around tents, which serve as an important supplementary food source in displacement contexts. Despite these concerns, no confirmed attacks on humans were documented during the study period.

Chiropteran fauna were represented by the Egyptian Fruit Bat (*Rousettus aegyptiacus* Geoffroy, 1810) (Figure 9), which exhibited a dual ecological association with both natural and highly disturbed habitats. Individuals were occasionally observed roosting in abandoned buildings, partially collapsed structures, and concrete ruins, while large nocturnal aggregations were frequently recorded flying over camps shortly after sunset. Additionally, communal roosting was observed in mature trees, particularly Date Palms (*Phoenix dactylifera* Linnaeus, 1753), Sycamore Fig (*Ficus sycomorus* Linnaeus, 1753), White Mulberry (*Morus alba* Linnaeus, 1753), and other large arboreal species that remain relatively abundant in central and southern Gaza Strip. Although this species is not considered a direct health threat, its conspicuous size, nocturnal activity, and large colony formations contribute to heightened perception of risk among displaced populations, particularly children and women, reflecting a strong socio-psychological dimension of human–wildlife interactions under crisis conditions.



Figure 8: Red Foxes (*Vulpes vulpes* Linnaeus, 1758) were repeatedly reported by displaced residents, particularly in camps near agricultural lands, orchards, and degraded peri-urban areas in the eastern Gaza Strip



Figure 9: The large size, nocturnal activity, and colonial behavior of the Egyptian Fruit Bat (*Rousettus aegyptiacus* Geoffroy, 1810) heightened fear and risk perception among displaced populations, particularly children and women, in the Gaza Strip

Table 1: Mammalian pests prevailing in Gaza displacement camps

Order	Family	Scientific Name	Common Name
Rodentia	Muridae	<i>Rattus norvegicus</i> Berkenhout, 1769	Norway Rat
Rodentia	Muridae	<i>Rattus rattus</i> Linnaeus, 1758	Black Rat
Rodentia	Muridae	<i>Mus musculus</i> Linnaeus, 1758	House Mouse
Carnivora	Felidae	<i>Felis catus</i> Linnaeus, 1758	Domestic or Feral Cat
Carnivora	Canidae	<i>Canis familiaris</i> Linnaeus, 1758	Domestic Dog
Carnivora	Canidae	<i>Canis aureus</i> Linnaeus, 1758	Golden Jackal
Carnivora	Canidae	<i>Vulpes vulpes</i> Linnaeus, 1758	Red Fox
Carnivora	Herpestidae	<i>Herpestes ichneumon</i> Linnaeus, 1758	Egyptian Mongoose
Chiroptera	Pteropodidae	<i>Rousettus aegyptiacus</i> Geoffroy, 1810	Egyptian Fruit Bat

3.2.2. Avian Pests

Scavenging and synanthropic birds were frequently observed around displacement camps and surrounding tented shelters throughout the Gaza Strip, particularly near refuse piles, food distribution points, sewage-affected areas, wastewater pools, and temporary waste disposal sites (Figure 10). Bird abundance was consistently higher in locations characterized by poor sanitation, abundant food waste, and intense human activity. Frequently encountered species included the Hooded Crow (*Corvus cornix* Linnaeus, 1758), Black Kite (*Milvus migrans* Boddaert, 1783), Feral Pigeon or Rock Dove (*Columba livia* Gmelin, 1789), gulls (*Larus* spp.), House Sparrow (*Passer domesticus* Linnaeus, 1758), and the invasive Common Myna (*Acridotheres tristis* Linnaeus, 1766).

Hooded Crows were among the most conspicuous birds, commonly foraging individually or in small flocks around refuse accumulation sites, animal carcasses, and food distribution centers. Black Kites were regularly observed soaring above displacement camps and waste dumps while scavenging on discarded food, animal remains, and other organic refuse. Feral Pigeons and House Sparrows occurred in high densities around tents and temporary shelters, feeding on spilled grains, bread remnants, and other food scraps generated by camp residents. Gulls, particularly during the winter season, were frequently recorded at open waste disposal areas and sewage-contaminated sites near the Mediterranean coast as well as inland displacement camps.

The Common Myna was commonly encountered in urban and peri-urban displacement settings, where it exploited a wide variety of anthropogenic food resources and nested in damaged buildings, abandoned structures, utility poles, and camp infrastructure.

Many of these species exhibited a high degree of tolerance to human presence, allowing close approaches to tents, communal kitchens, food storage areas, and water collection points. Large mixed-species aggregations were frequently observed at refuse accumulation sites, especially following waste disposal or humanitarian food distribution activities. Birds regularly moved between waste dumps, sewage-contaminated environments, livestock enclosures, and densely populated displacement camps while searching for food, water, and nesting materials.

Field observations further recorded birds feeding on organic refuse, dead rodents, fish remains, slaughter waste, discarded household food, insects, and other invertebrates associated with decomposing organic matter. Nesting activity was documented in damaged buildings, partially collapsed structures, trees surrounding camps, utility poles, and abandoned infrastructure. Feral Pigeons were particularly common around tents and communal shelters, where droppings frequently accumulated on shelter roofs, food storage areas, and water containers. Hooded Crows, Black Kites, and gulls were repeatedly observed moving between refuse dumps, animal carcasses, and areas of human activity, whereas House Sparrows and Common Mynas were commonly associated with food preparation and storage areas within the camps.

Additional opportunistic species, including the Barn Swallow (*Hirundo rustica* Linnaeus, 1758) and White-throated Kingfisher (*Halcyon smyrnensis* Linnaeus, 1758), were occasionally recorded around water points and open spaces, where insect activity was relatively high. Overall, the widespread occurrence of synanthropic birds across displacement camps reflected their successful exploitation of the altered environmental conditions resulting from prolonged infrastructure destruction, waste accumulation, and deteriorating sanitation throughout the Gaza Strip (Figure 10).

Table 2: Bird species recorded in Gaza displacement camps with potential roles as mechanical transmitters of pathogens and environmental contaminants

Order	Family	Scientific Name	Common Name
Passeriformes	Corvidae	<i>Corvus cornix</i> Linnaeus, 1758	Hooded Crow
Passeriformes	Sturnidae	<i>Acridotheres tristis</i> Linnaeus, 1766	Common Myna
Passeriformes	Passeridae	<i>Passer domesticus</i> Linnaeus, 1758	House Sparrow
Charadriiformes	Laridae	<i>Larus ridibundus</i> Linnaeus, 1766	Black-headed Gull
Charadriiformes	Laridae	<i>Larus michahellis</i> Naumann, 1840	Yellow-legged Gull
Pelecaniformes	Ardeidae	<i>Bubulcus ibis</i> Linnaeus, 1758	Cattle Egret
Accipitriformes	Accipitridae	<i>Milvus migrans</i> Boddaert, 1783	Black Kite
Columbiformes	Columbidae	<i>Columba livia</i> Gmelin, 1789	Feral Pigeon (Rock Dove)

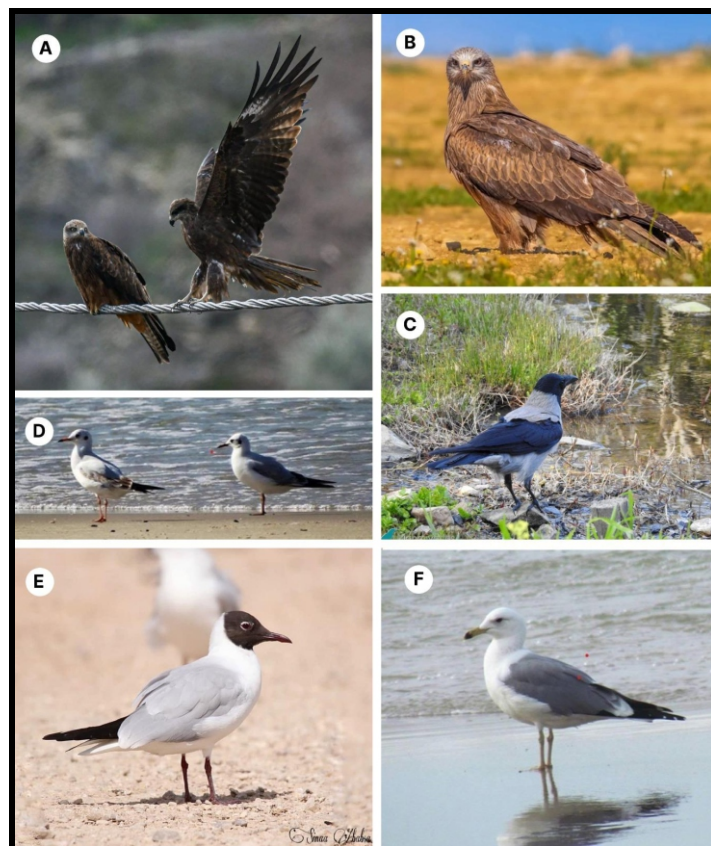


Figure 10: Avian scavengers act as highly mobile ecological connectors between waste accumulation sites and displacement camps in the Gaza Strip, with the potential to mechanically transmit pathogens and environmental contaminants: (A & B) Black Kite (*Milvus migrans* Boddaert, 1783); (C) Hooded Crow (*Corvus cornix* Linnaeus, 1758); (D & E) Black-headed Gull (*Larus ridibundus* Linnaeus, 1766); and (F) Yellow-legged Gull (*Larus michahellis* Naumann, 1840)

3.2.3. Reptilian Pests

Reptiles were widely distributed throughout displacement camps (Table 3), particularly in areas containing extensive rubble, collapsed buildings, abandoned structures, unmanaged vegetation, and construction debris. These habitats provide abundant shelter, thermoregulatory sites, and access to prey, particularly rodents and insects. Snakes represented the most medically important reptilian pests. The Palestine Viper (*Daboia palaestinae* Werner, 1938), the principal venomous snake in the Gaza Strip, was considered the species of greatest public health concern because of its highly venomous bite and the limited availability of emergency medical services during wartime (Figure 11). The Palestine Saw-scaled Viper (*Echis coloratus* Günther, 1878) is another venomous snake that is rarely encountered in the Gaza Strip, particularly in its southern belt. In addition to these medically significant vipers, the recorded snake fauna included a mixture of non-venomous species and others possessing only mild, rear-fanged (opisthoglyphous) venom. This type of venom is primarily adapted for subduing small prey and is not considered of major medical importance to humans under normal circumstances. Most of the remaining species are harmless and rely on constriction or active predation rather than venom to capture prey, and overall do not represent a serious envenomation risk.

In field settings, however, many of these snakes—whether venomous or non-venomous—are frequently killed by displaced people, particularly young men, driven by fear and panic within densely populated tented environments where encounters with snakes are distressing, especially for children and women (Figure 11). Social media platforms, and at times local news pages, often display images of these snakes accompanied by questions regarding their identity and level of danger. Because most people cannot easily distinguish between venomous and non-venomous species, such posts are widespread, and responses are often provided by specialists or individuals with field experience to clarify the species and their actual risk level.

Large lizards, particularly the Desert Monitor (*Varanus griseus* Daudin, 1803), were occasionally encountered near camp margins and agricultural areas. Although they generally avoiding direct contact with humans, their large body size frequently caused alarm among displaced residents (Figure 12). Smaller reptiles, including Schneider's Skink (*Eumeces schneiderii* Daudin, 1802), Mediterranean House Gecko (*Hemidactylus turcicus* Linnaeus, 1758), Bosc's Fringe-fingered Lizard (*Acanthodactylus boskianus* Daudin, 1802), and Starred Agama (*Stellagama stellio* Linnaeus, 1758), were common around tents, concrete blocks, stone piles, and damaged buildings. While these lizards pose little direct medical risk, their frequent presence inside shelters generates discomfort and anxiety among many camp residents, particularly children. Overall, reptiles have become increasingly associated with displacement camps owing to the abundance of refuge sites created by war-related destruction and the expansion of rodent populations that provide an abundant prey base.



Figure 11: Venomous and non-venomous snakes pose increasing risks to inhabitants of displacement camps across the Gaza Strip: (A–C) Palestine Viper (*Daboia palaestinae* Werner, 1938), the principal endemic venomous snake in Palestine; (D) Montpellier Snake (*Malpolon monspessulanus* Hermann, 1804); (E) Schokari Sand Racer (*Psammophis schokari* Forsskål, 1775); and (F) Syrian Black Snake (*Dolichophis jugularis* Linnaeus, 1758)



Figure 12: The Desert Monitor (*Varanus griseus* Daudin, 1803), the largest lizard in the Gaza Strip (80–120 cm total length), is occasionally seen near displacement camps and agricultural areas, where its large size often alarms residents despite avoiding human contact

Table 3: Reptilian pests prevailing in Gaza displacement camps

Order	Family	Scientific Name	Common Name
Squamata	Viperidae	<i>Daboia palaestinae</i> Werner, 1938	Palestine Viper
Squamata	Viperidae	<i>Echis coloratus</i> Günther, 1878	Palestine Saw-scaled Viper*
Squamata	Psammophiidae	<i>Malpolon monspessulanus</i> Hermann, 1804	Montpellier Snake
Squamata	Psammophiidae	<i>Psammophis schokari</i> Forsskål, 1775	Schokari Sand Racer
Squamata	Boidae	<i>Eryx jaculus</i> Linnaeus, 1758	Sand Boa
Squamata	Colubridae	<i>Platycephalus rogersi</i> Anderson, 1893	Rogers' Racer
Squamata	Colubridae	<i>Hemorrhois nummifer</i> Reuss, 1834	Coin-marked Snake
Squamata	Colubridae	<i>Dolichophis jugularis</i> Linnaeus, 1758	Syrian Black Snake
Squamata	Colubridae	<i>Dolichophis schmidtii</i> Nikolsky, 1909	Red-bellied Racer
Squamata	Colubridae	<i>Spalerosophis diadema</i> Schlegel, 1837	Clifford's Royal Snake
Squamata	Varanidae	<i>Varanus griseus</i> Daudin, 1803	Desert Monitor
Squamata	Scincidae	<i>Eumeces schneiderii</i> Daudin, 1802	Schneider's Skink
Squamata	Gekkonidae	<i>Hemidactylus turcicus</i> Linnaeus, 1758	Mediterranean House Gecko
Squamata	Lacertidae	<i>Acanthodactylus boskianus</i> Daudin, 1802	Bosc's Fringe-fingered Lizard
Squamata	Agamidae	<i>Stellagama stellio</i> Linnaeus, 1758	Starred Agama

*Very rare

3.2.4. Amphibian Species Associated with Displacement Camps

Three amphibian species were recorded in and around displacement camps (Table 4): The Levant Water Frog (*Pelophylax bedriagae* Camerano, 1882), the Middle Eastern Tree Frog (*Hyla savignyi* Audouin, 1827), and the European Green Toad (*Bufo viridis* Laurenti, 1768). Unlike other vertebrate groups described in this study, amphibians do not represent direct pests. Nevertheless, their occurrence provides an important ecological indicator of deteriorating environmental sanitation. Their presence was closely associated with stagnant wastewater, damaged drainage systems, sewage leakage, temporary rainwater pools, and persistently humid habitats surrounding tents. Among the recorded species, the Levant Water Frog was the principal source of nocturnal acoustic disturbance because of its loud and prolonged breeding calls (Figure 13). The Middle Eastern Tree Frog also produced repeated nocturnal vocalizations that frequently disturbed camp residents. In contrast, the European Green Toad produced weaker seasonal calls, making it a comparatively minor source of nuisance. Although amphibians contribute to natural regulation of insect populations through predation, their occurrence reflects the persistence of standing water and degraded sanitary conditions that simultaneously promote mosquito breeding and other vector-borne public health risks.



Figure 13: The Levant Water Frog (*Pelophylax bedriagae* Camerano, 1882), one of three frog species in the Gaza Strip, is the principal source of nocturnal acoustic disturbance in and around displacement camps because of its loud, prolonged breeding calls

Table 4: Amphibian pests prevailing in Gaza displacement camps

Order	Family	Scientific Name	Common Name
Anura	Ranidae	<i>Pelophylax bedriagae</i> Camerano, 1882	Levant Water Frog
Anura	Hylidae	<i>Hyla savignyi</i> Audouin, 1827	Middle Eastern Tree Frog
Anura	Bufonidae	<i>Bufo viridis</i> Laurenti, 1768	European Green Toad

3.3. Ecological Drivers Influencing Vertebrate Pest Proliferation

The proliferation of vertebrate pests across displacement camps in the Gaza Strip is strongly linked to severe war-induced environmental degradation, which has fundamentally reshaped urban ecological systems (Table 5). As described in Sections 3.1 and 3.2, large-scale destruction of infrastructure, extensive rubble accumulation, collapse of sanitation networks, and the breakdown of municipal services have collectively generated highly favorable conditions for opportunistic and synanthropic species. These disturbances have simultaneously increased resource availability while reducing ecological regulation and human-mediated pest control.

Table 5: Major ecological drivers, ecological responses, and public health implications of vertebrate pest groups associated with displacement camps in the Gaza Strip

Vertebrate Group	Dominant Ecological Drivers	Ecological Responses	Public Health / Camp Implications
Rodents	- Accumulation of refuse and organic waste. - Damaged sewage and drainage networks. - Extensive rubble and collapsed buildings. - Breakdown of municipal pest control.	- Rapid population growth due to high reproductive rates. - Occupation of tents, shelters, rubble, and drainage systems. - High adaptability and omnivorous feeding behavior.	- Food contamination and property damage. - Potential transmission of rodent-borne diseases. - Major prey base supporting snake populations.
Free-ranging Dogs	- Abandoned domestic animals. - Abundant food waste and livestock carcasses. - Lack of veterinary care and population control.	- Formation of semi-feral packs. - Frequent aggregation around camps, refuse sites, and food distribution points.	- Human-dog conflicts and bite injuries. - Potential zoonotic disease transmission. - Increased fear and insecurity among camp residents.
Feral Cats	- High rodent abundance. - Discarded food waste. - Shelter within damaged buildings and rubble.	- High breeding success. - Opportunistic scavenging combined with rodent predation.	- Potential transmission of <i>Toxoplasma gondii</i> and ectoparasites. - Partial suppression of rodent populations through predation.
Wild Carnivores (Red Fox, Golden Jackal & Egyptian Mongoose)	- Habitat destruction. - Reduced prey availability in natural habitats. - Increased food resources around camps. - Proximity of camps to agricultural and peri-urban areas.	- Opportunistic foraging around camp margins. - Periodic incursions into displacement camps and surrounding settlements.	- Occasional predation on poultry and small domestic animals. - Increased human-wildlife encounters and perceived safety concerns.

Egyptian Fruit Bat	• Availability of abandoned buildings and partially collapsed structures. • Presence of mature fruit trees. • Reduced human disturbance in ruined areas.	• Roosting in damaged buildings and large trees. • Nocturnal foraging flights over camps.	• Limited direct public health importance. • Increased fear and psychological discomfort due to large body size and nocturnal activity.
Scavenging Birds	• Refuse accumulation. • Open sewage. • Livestock carcasses. • Food distribution areas.	• Aggregation around waste-rich habitats. • High mobility between camps and surrounding urban environments.	• Mechanical transmission of pathogens. • Contamination of food preparation and living areas by droppings. • Deterioration of environmental hygiene.
Reptiles	• Rubble, concrete crevices, and abandoned buildings. • Unmanaged vegetation. • Increased rodent and insect prey availability.	• Expansion of shelter and thermoregulatory sites. • Increased activity around human shelters. • Greater frequency of human–snake encounters.	• Risk of venomous snakebite (primarily <i>Daboia palaestinae</i>). • Widespread fear leading to indiscriminate killing of both venomous and non-venomous snakes. • Psychological stress among displaced residents.
Amphibians	• Stagnant rainwater and wastewater. • Sewage leakage. • Damaged drainage systems. • Persistently humid habitats.	• Rapid colonization of temporary aquatic habitats. • Increased nocturnal breeding and vocal activity.	• Acoustic nuisance, particularly from frogs. • Indicators of deteriorating sanitation and habitats favorable for mosquito breeding rather than direct pest species.

A primary driver of pest expansion is habitat transformation. The widespread presence of collapsed buildings, debris fields, abandoned structures, and unmanaged vegetation has created extensive sheltering, nesting, and thermoregulatory microhabitats for rodents, reptiles, and other vertebrates. In parallel, the continuous accumulation of solid waste, organic refuse, sewage leakage, and stagnant wastewater has significantly increased food availability and breeding substrates, particularly for rodent populations, which constitute the most responsive and rapidly expanding group under these conditions. Their high reproductive rates, omnivorous diet, and strong adaptability to disturbed environments further amplify their dominance across camp settings.

Secondary ecological drivers include the collapse of sanitation infrastructure and the cessation of systematic pest control programs. These factors have allowed free-ranging domestic animals and synanthropic wildlife to proliferate without regulation. Free-ranging dogs have increased in association with abandoned ownership, unrestricted access to food waste, and the absence of vaccination or population control measures. Similarly, feral cats benefit from abundant rodent prey and organic waste sources, as well as the availability of shelter within damaged buildings and dense camp structures.

Avian scavengers have also responded strongly to these altered conditions, exploiting refuse piles, carcasses, and food distribution points, with high mobility enabling frequent interchange between camps and surrounding urban ruins. Reptilian species, particularly snakes and lizards, have expanded in response to increased prey availability—especially rodents—and the proliferation of refuges within rubble, construction debris, and abandoned infrastructure. Amphibian occurrences, while not directly classified as pest outbreaks, further reflect the persistence of stagnant water bodies and degraded drainage systems, indicating ongoing environmental deterioration.

Overall, these interacting ecological processes demonstrate a profound restructuring of urban ecosystems under war conditions, favoring highly adaptable vertebrate species capable of exploiting anthropogenic resources and surviving in highly disturbed environments.

This has resulted in increased human–wildlife interactions and a marked rise in the ecological and public health significance of synanthropic vertebrate assemblages within displacement camps.

3.4. Public Health and Humanitarian Implications of Vertebrate Pest Proliferation

3.4.1. Public Health Risks

Vertebrate pests constitute a major public health concern within displacement camps owing to their direct and indirect impacts on human health. Rodents are among the principal health threats because of their role in contaminating food and water supplies and their potential to transmit zoonotic pathogens, including *Leptospira spp.*, *Salmonella spp.*, and other bacterial agents. Field observations indicated frequent rodent intrusion into tents, food storage areas, and humanitarian supply stocks, resulting in food contamination and material damage. Free-ranging dogs pose additional risks through bite injuries and the potential transmission of zoonotic diseases, particularly in the absence of veterinary vaccination and population control programs. Feral cats may contribute to the transmission of *Toxoplasma gondii* and ectoparasites, whereas scavenging birds facilitate the mechanical spread of environmental contaminants between refuse sites, sewage-affected areas, and human settlements. Reptiles, particularly the Palestine Viper (*Daboia palaestinae* Werner, 1938), represent the most important direct medical hazard because of the severity of envenomation and the limited availability of emergency medical care during wartime. Although most other snake species recorded in this study are non-venomous or only mildly venomous, their frequent occurrence around shelters increases human–snake encounters and contributes to perceived health risks among displaced populations.

3.4.2. Environmental, Humanitarian, and Socio-economic Impacts

The proliferation of vertebrate pests further exacerbates environmental degradation and humanitarian challenges within displacement camps. Rodents damage tents, food containers, clothing, electrical cables, and stored humanitarian supplies while contaminating food reserves, thereby increasing material losses for already food-insecure households.

Free-ranging dogs, feral cats, and scavenging birds disperse refuse and organic waste, further reducing environmental hygiene and complicating waste management efforts. The persistence of carcasses, sewage leakage, and unmanaged refuse creates positive feedback loops that sustain both vertebrate and invertebrate pest populations. Ecologically, these changes reflect a marked shift toward disturbance-tolerant synanthropic species at the expense of more sensitive native fauna, indicating profound alteration of urban ecosystem structure and function. From a humanitarian perspective, frequent encounters with rodents, snakes, stray dogs, and other vertebrates generate persistent fear, anxiety, sleep disturbance, and reduced perceptions of safety, particularly among children and women living in densely populated tents. These conditions also impose additional socio-economic burdens through the repeated loss of household belongings, increased reliance on humanitarian assistance, and growing demand for already overstretched public health and municipal services.

Table 6: Relative risk ranking of vertebrate pests affecting displaced populations in Gaza displacement camps

Vertebrate group	Relative risk	Primary impacts
Rodents	Very High	Food contamination, zoonotic diseases, damage to shelters and stored supplies, support of snake populations
Venomous snakes	Very High	Snakebite, medical emergencies, severe psychological fear
Free-ranging dogs	High	Bite injuries, aggressive behavior, zoonotic disease transmission
Feral cats	Moderate	Toxoplasmosis, ectoparasites, food contamination, limited rodent suppression
Scavenging birds	Moderate	Mechanical transmission of pathogens, contamination of food and living areas
Wild carnivores	Low	Occasional poultry predation and sporadic human–wildlife conflicts
Egyptian Fruit Bat	Low	Mainly psychological discomfort with negligible direct health risk
Amphibians	Very Low	Acoustic nuisance and indicators of deteriorated sanitation

Rodents represent the highest-priority vertebrate pests because of their widespread abundance, continuous contamination of food and water, destruction of stored humanitarian supplies, and their role as reservoirs or potential carriers of numerous zoonotic pathogens. Furthermore, their high population densities indirectly increase the occurrence of predatory snakes by providing an abundant prey base.

Venomous snakes, particularly the Palestine Viper (*Daboia palaestinae*), constitute the second most important threat because even relatively infrequent encounters may result in severe envenomation, while wartime conditions substantially limit access to emergency medical treatment. Although only two venomous snake species were recorded, their presence generates considerable fear and psychological distress among displaced populations.

Free-ranging dogs rank third owing to their frequent presence around camps, aggressive behavior, bite injuries, and potential transmission of zoonotic diseases. Feral cats occupy an intermediate position because, although they contribute to rodent suppression, they may contaminate food preparation areas and serve as reservoirs of parasites such as *Toxoplasma gondii*.

Scavenging birds primarily contribute to environmental contamination through mechanical transport of pathogens between refuse, sewage, carcasses, and human food sources, whereas wild carnivores represent only occasional localized concerns, mainly through predation on small domestic animals. Egyptian Fruit Bats have minimal direct public health significance but frequently provoke fear because of their large body size and nocturnal activity. Amphibians constitute the lowest-risk vertebrate group, functioning mainly as ecological indicators of poor sanitation while causing only localized nocturnal acoustic disturbance.

3.5. Relative Risk Ranking of Vertebrate Pests in Gaza Displacement Camps

Not all vertebrate pests associated with displacement camps pose the same level of risk to displaced populations. Based on field observations, reported human–wildlife encounters, ecological characteristics of the recorded species, and their potential public health and humanitarian impacts, vertebrate pest groups can be ranked according to their relative importance (Table 6). This ranking integrates multiple criteria, including frequency of occurrence, direct threat to human health, disease transmission potential, economic damage, environmental contamination, and psychological impacts on camp residents.

3.6. Integrated Pest Management Priorities for Vertebrate Pests in Gaza Displacement Camps

Effective management of vertebrate pests in Gaza displacement camps should adopt the principles of Integrated Pest Management (IPM), emphasizing environmental restoration, sanitation, surveillance, public awareness, and targeted control measures rather than indiscriminate extermination. Because vertebrate pest proliferation is primarily driven by war-induced environmental degradation, priority interventions should focus on restoring solid waste collection, improving sanitation and drainage infrastructure, ensuring safe food storage, and optimizing camp layouts to minimize shelter and food resources for pest species. Rodent management should integrate environmental sanitation, continuous monitoring, trapping, and the judicious use of rodenticides by trained personnel within a coordinated pest management program. Management of free-ranging dogs and feral cats should include vaccination, sterilization, parasite control, and humane population management supported by veterinary services. Risks associated with reptiles, particularly venomous snakes, can be reduced through systematic removal of rubble and construction debris surrounding shelters, vegetation management, community education on snake identification and avoidance, and improved access to first aid and emergency medical care for snakebite victims. Management of scavenging birds should focus primarily on eliminating food attractants through effective refuse collection, prompt removal of animal carcasses, and protection of food storage and preparation areas rather than direct population control. Wild carnivores, including foxes, jackals, and mongooses, as well as Egyptian Fruit Bats, generally require no direct control measures; instead, reducing anthropogenic food resources and minimizing opportunities for human–wildlife interactions are sufficient to limit conflicts.

Likewise, amphibians should not be targeted directly, as their occurrence primarily reflects deteriorated environmental conditions. Improving drainage systems and eliminating stagnant wastewater will simultaneously reduce amphibian abundance and mosquito breeding habitats. Community participation remains essential for early reporting of pest activity, public education, and implementation of preventive measures. Ultimately, sustainable reduction of vertebrate pest populations depends on large-scale environmental recovery through reconstruction of housing and public infrastructure, restoration of sanitation services, effective waste management, and rehabilitation of urban ecosystems. These interventions address the underlying ecological drivers sustaining vertebrate pest proliferation while simultaneously improving public health, environmental quality, and humanitarian conditions within displacement camps.

4. DISCUSSION

The findings of this study demonstrate that the prolonged armed conflict in the Gaza Strip (2023–2026) has fundamentally restructured urban ecological systems, resulting in highly simplified, disturbance-driven vertebrate communities within displacement camps. These systems are dominated by synanthropic species that rapidly exploit anthropogenic resources generated by the collapse of sanitation, waste management, housing, and governance infrastructures. This pattern aligns with global evidence from urban ecology and conflict-driven environmental disruption, where ecosystem instability reshapes human–animal–pathogen interfaces and facilitates opportunistic wildlife assemblages [19] [20] [61]–[63]. In war settings such as the Gaza Strip, emerging scholarship has further emphasized the need to recognize non-human organisms as indirect victims of war, highlighting how armed conflict reshapes ecological systems and produces widespread environmental suffering beyond human populations [64].

Rodents emerged as the most ecologically dominant and epidemiologically significant vertebrate group. Their proliferation is strongly associated with persistent food waste accumulation, sewage leakage, and rubble formation, all of which provide ideal conditions for reproduction and survival [65]. Similar environmental and sanitary deterioration patterns have been documented in refugee camp settings, where overcrowding, inadequate waste disposal, and poor sanitation contribute to increased rodent abundance and associated public health risks [66]. Comparable dynamics have also been widely reported in post-disaster and densely urbanized environments, where breakdowns in sanitation systems trigger rapid increases in rodent populations and elevated zoonotic disease risks [34] [65] [67]–[69]. Recent humanitarian reports from the war-affected Gaza Strip confirm severe rodent infestations in displacement camps, including contamination of food and water supplies and direct intrusion into shelters [42]. In the Gaza Strip, deteriorated sanitation and contamination of water systems have been strongly associated with the persistence and transmission of intestinal parasitic infections, reflecting the close relationship between environmental conditions and public health outcomes [70]. Rodents are increasingly recognized as key reservoirs and amplifiers of zoonotic pathogens in urban ecosystems undergoing environmental stress [37] [71]–[73].

Studies conducted in the Gaza Strip have confirmed that both the Black Rat and the House Mouse harbor diverse gastrointestinal parasites and ectoparasites, highlighting their direct epidemiological role in local disease transmission cycles [74] [75]. This reinforces their importance as major public health threats in overcrowded displacement camps where sanitation systems have collapsed. The expansion of free-ranging dogs and feral cats reflects a parallel collapse in domestic animal control systems. Free-ranging dogs exhibit scavenging behavior driven by waste availability and the absence of regulatory control, thereby increasing risks of bites and potential pathogen transmission. These patterns are consistent with observations from humanitarian crisis settings, where breakdowns in animal management systems contribute to heightened human–dog conflict and elevated disease exposure [61] [76]. In war-affected urban environments such as the Gaza Strip, the ecology and social presence of free-ranging dogs have also been interpreted within broader socio-political and structural violence frameworks, highlighting how armed conflict reshapes human–animal relations and urban animal populations [77]. In the West Bank of Palestine, domestic and free-ranging dogs have been identified as important reservoirs of zoonotic parasites, including the Dog or Hydatid Tapeworm (*Echinococcus granulosus* Batsch, 1786), underscoring their epidemiological significance in the transmission of neglected zoonotic diseases [78] [79]. Feral cats may contribute to partial rodent suppression; however, they also introduce additional risks associated with parasitic infections and environmental contamination. In the Gaza Strip, stray cats have been shown to harbor a wide range of intestinal parasites, including *Toxoplasma gondii*, highlighting their role as important reservoirs of zoonotic infection in urban and peri-domestic environments [80]. This reflects complex mesopredator dynamics in disturbed ecosystems, where synanthropic species thrive under conditions of environmental collapse [69] [81]. Furthermore, the Israeli military occupation operations in the Gaza Strip have led to significant biological disruptions. The collapse of border infrastructure has reportedly facilitated the movement of approximately one thousand stray dogs from the Gaza Strip into the surrounding areas in southern occupied Palestine, known as the "Gaza Envelope". In these areas, these stray dogs have altered the local predation dynamics by preying on native wildlife, such as deer. They have also reportedly come into contact with Israeli occupation forces stationed in and around the Gaza Strip, causing panic among them and impacting their military aggression against the Gaza Strip population [82]. Wild carnivores such as foxes, jackals, and mongooses represent a secondary ecological response to large-scale habitat destruction and prey redistribution. Their occasional incursion into peri-camp environments reflects increasing permeability between natural and anthropogenic landscapes, a phenomenon frequently documented in war-affected ecosystems [18] [20]. In the Gaza Strip, ecological studies have documented the occurrence and behavioral ecology of the Golden Jackal, highlighting its adaptability to disturbed habitats and its ability to exploit peri-urban environments influenced by human activity and waste availability [83]. Similar patterns of opportunistic behavior and rare but high-impact predator–human interactions have also been reported in large carnivores such as the Desert Lynx or Caracal (*Caracal caracal* Schreber, 1776), including documented aggressive encounters under disturbed environmental conditions in the Negev Desert in southern Palestine [84].

Comparable incidents have also involved Golden Jackals (*Canis aureus* Linnaeus, 1758), with a pack reportedly attacking Israeli tourists camping near Lake Tiberias (the Sea of Galilee), the largest freshwater lake in the region, situated in the northern part of the Jordan Rift Valley in northern occupied Palestine, resulting in multiple injuries [85]. Such events, although uncommon, illustrate the potential for altered wildlife behavior and increased human–carnivore conflicts under conditions of environmental disturbance and food scarcity. These shifts collectively indicate a landscape-level reorganization of trophic structures under extreme anthropogenic pressure.

Although wild carnivores were infrequently observed directly, they were repeatedly reported by displaced residents, particularly in camps located near agricultural lands, orchards, and heavily degraded peri-urban fringes, mainly in the eastern parts of the Gaza Strip. Reported species included the Red Fox (*Vulpes vulpes* Linnaeus, 1758), Golden Jackal (*Canis aureus* Linnaeus, 1758), and Egyptian Mongoose (*Herpestes ichneumon* Linnaeus, 1758). In addition, sporadic occurrences of the Arabian Wolf (*Canis lupus* Linnaeus, 1758) have been reported in the eastern Gaza Strip, reflecting rare but ecologically significant expansions of large carnivores into human-modified landscapes [86]. While direct observations were limited, interview data suggest intermittent incursions of these species into camp peripheries, likely driven by habitat destruction, reduced prey availability in natural areas, and increased foraging opportunities in waste-rich environments. Residents expressed particular concern about potential predation on small livestock such as chickens and ducks kept around tents, which constitute an important supplementary food source in displacement settings. Despite these concerns, no confirmed attacks on humans were documented during the study period.

Reptilian assemblages demonstrate a particularly strong ecological response to environmental degradation. The widespread accumulation of rubble, collapsed buildings, damaged infrastructure, construction debris, unmanaged solid waste, and abandoned properties has created numerous artificial refuges and thermally suitable microhabitats that facilitate reptile sheltering, reproduction, and overwintering. Simultaneously, the proliferation of rodents and other small vertebrates provides abundant prey resources, enhancing habitat suitability for both venomous and non-venomous snake species as well as predatory lizards. Consequently, disturbed urban landscapes and displacement camps increasingly function as novel ecological habitats that promote closer spatial overlap between reptiles and human populations. Venomous species, particularly the Palestine Viper (*Daboia palaestinae* Werner, 1938), acquire heightened medical significance because environmental degradation, overcrowded living conditions, nighttime outdoor activities, and severely restricted healthcare services collectively increase the likelihood and consequences of human–snake encounters [87] [88]. Similar increases in snakebite risk have been documented in other humanitarian crises and disaster-affected regions, where habitat disturbance and displacement force wildlife into closer proximity with humans. In addition to snakes, several lizard species commonly associated with rubble, stone walls, and abandoned structures may also increase in abundance, reflecting the broader restructuring of reptilian communities under conditions of prolonged environmental disturbance. Nevertheless, reptiles also perform important ecological functions within these degraded ecosystems.

As mesopredators, snakes contribute to regulating rodent populations and may partially suppress pest outbreaks, thereby providing valuable ecosystem services despite posing direct hazards to humans [89] [90]. This dual role creates a functional paradox in which reptiles simultaneously support ecosystem stability through biological pest control while representing significant public health threats under conditions of environmental collapse, illustrating the complex ecological trade-offs characteristic of disturbed urban ecosystems [81].

Avian scavengers act as highly mobile ecological connectors between waste accumulation sites and human settlements [91] [92]. Comprehensive ornithological surveys conducted in the Gaza Strip have documented a diverse avifauna comprising resident, migratory, and synanthropic species inhabiting a wide range of natural, agricultural, and urban ecosystems [93]–[96]. Several species, particularly Hooded Crows, gulls, mynas, pigeons, doves, and House Sparrows, are closely associated with human settlements and readily exploit anthropogenic food resources, including refuse accumulation sites, open waste dumps, and displacement camps. Their remarkable ecological plasticity enables them to thrive under conditions of severe environmental disturbance and infrastructure collapse. Although these birds provide important ecosystem services through scavenging and waste removal, their ecological role in heavily degraded urban environments may shift toward the mechanical dissemination of pathogens and environmental contaminants [97]. Among these species, the invasive Indian Myna (*Acridotheres tristis* Linnaeus, 1766) has become firmly established in urban habitats throughout the Gaza Strip, where its adaptability, aggressive behavior, and close association with anthropogenic food sources have raised concerns regarding ecological disturbance, agricultural damage, nuisance impacts, and potential disease transmission [98]. This ecological transition illustrates the context-dependent nature of avian ecosystem functions under extreme anthropogenic disturbance and prolonged humanitarian crises [38] [99].

Amphibians, although not considered direct pest species in the Gaza Strip, represent valuable ecological indicators of environmental degradation due to their permeable skin, aquatic-dependent life stages, and high sensitivity to changes in habitat conditions, water quality, and pollution levels. Their presence is often associated with stagnant water bodies, sewage leakage, poor drainage systems, and wastewater accumulation—conditions that indicate inadequate sanitation and environmental management, which have become particularly pronounced in the Gaza Strip. At the same time, these conditions provide suitable breeding habitats for mosquitoes and other disease vectors, creating indirect links between amphibian habitats, ecosystem deterioration, and public health risks. Changes in amphibian abundance, distribution, and reproductive activity can therefore provide early evidence of declining water quality, habitat disturbance, and infrastructure failure [9] [62] [100] [101]. In highly disturbed environments, including densely populated and displacement settings, amphibians may serve as useful bioindicators of ecological imbalance, reflecting the combined impacts of poor wastewater management, standing water accumulation, and degraded urban ecosystems while highlighting conditions that facilitate vector proliferation and disease emergence [102] [103]. From a systemic perspective, the observed vertebrate assemblages reflect a breakdown of the human–animal–environment interface as conceptualized within the One Health framework.

The proliferation of synanthropic species is not an isolated ecological event but rather an emergent property of interconnected failures in infrastructure, governance, waste management, and public health systems [4] [59]. In this context, vertebrate pests function as reliable bioindicators of environmental degradation intensity and system collapse.

Beyond epidemiological consequences, vertebrate pest proliferation imposes substantial psychosocial burdens on displaced populations. Continuous exposure to rodents, snakes, and free-ranging dogs contributes to heightened fear, anxiety, and reduced perceived safety, particularly among children [104]. Such psychosocial impacts are increasingly recognized in conflict ecology literature as integral components of environmental health deterioration [62] [105] [106].

Overall, vertebrate communities in displacement camps represent a biological manifestation of infrastructural failure and environmental collapse. Their emergence reflects not only ecological opportunism but also systemic breakdown in urban environmental services, making them robust indicators of humanitarian crisis severity and ecological instability [11] [38] [60] [107]-[108].

5. CONCLUSION

Displacement camps in the Gaza Strip represent severely degraded urban ecosystems shaped by war-induced environmental collapse. The destruction of infrastructure, solid waste accumulation, and sanitation failure have created favorable conditions for synanthropic vertebrate pests. Rodents pose the greatest public health concern due to their abundance, contamination of food and water sources, and role in zoonotic disease transmission. Free-ranging dogs, venomous snakes and other vertebrate groups, including feral cats, scavenging birds, reptiles, and amphibians, contribute to varying ecological and health risks while reflecting the severity of environmental degradation. Vertebrate pest proliferation is therefore not an isolated biological issue but a consequence of systemic environmental and infrastructural breakdown. Effective mitigation requires long-term interventions targeting sanitation restoration, waste management, and improved environmental conditions.

ACKNOWLEDGMENT

The authors would like to express their sincere gratitude to everyone who contributed, directly or indirectly, to the preparation of this article and helped bring it to its present form. Special appreciation is extended to the displaced people throughout the Gaza Strip, particularly those in the Deir Al-Balah and Al-Mawasi displacement areas, whose cooperation, observations, and valuable field insights constituted an essential foundation for this study despite the extremely difficult humanitarian conditions. The authors also express their heartfelt thanks to the Palestinian wildlife photographers who generously provided several of the illustrative photographs used in this article, thereby enhancing its scientific documentation and visual presentation. Finally, the authors gratefully acknowledge all colleagues and individuals who offered encouragement, technical assistance, and constructive feedback throughout the preparation of this work. Their support is sincerely appreciated.

REFERENCES

1. London, L., Watterson, A., Mergler, D., Albin, M., Andrade-Rivas, F., Di Ciaula, A., Comba, P., Giannasi, F., Habib, R. R., Hay, A., Hoppin, J., Infante, P., Jeebhay, M., Kelsey, K., Kim, R., Lemen, R., Lipscomb, H., Lynge, E., Magnani, C., ... White, R. (2024). A call from 40 public health scientists for an end to the continuing humanitarian and environmental catastrophe in Gaza. *Environmental Health*, 23(1), 59. <https://doi.org/10.1186/s12940-024-01097-9>
2. Shaheen, A., Dajani, R., Zinszer, K., Ashour, Y., & Abuzerr, S. (2024). The war on the Gaza Strip and its consequences on global warming. *Frontiers in Human Dynamics*, 6, 1463902. <https://doi.org/10.3389/fhumd.2024.1463902>
3. Al-Agha, M. R. (1997). Environmental management in the Gaza Strip. *Environmental Impact Assessment Review*, 17(1), 65–76.
4. Abuawad, A., Griffiths, M., Edwards, G. H., Eftekhari, A., Al-Ebweini, M., Al-Najar, H., ... & Aker, A. (2025). The ongoing environmental destruction and degradation of Gaza: The resulting public health crisis. *American Journal of Public Health*, 115(7), 1053–1061.
5. Abd Rabou, A. N. (2011a). Environmental impacts associated with the Beit Lahia wastewater treatment plant, North Gaza Strip, Palestine. *Middle-East Journal of Scientific Research (MEJSR)*, 7(5), 746–757.
6. Boussaa, S., Dardona, Z., & Amame, M. (2025). Challenges and risk factors for infectious diseases in Gaza due to the current conflict. *Eastern Mediterranean Health Journal*, 31, 127–133.
7. Caniato, M., & Vaccari, M. (2014). How to assess solid waste management in armed conflicts? A new methodology applied to the Gaza Strip, Palestine. *Environmental Science & Policy*, 42, 101–112. <https://doi.org/10.1177/0734242X14543553> *(Note: Source identity adjusted for journal accuracy)*.
8. Al-Najar, H., & Nassar, A. R. (2019). Slaughterhouses wastewater characteristics in the Gaza Strip. *Journal of Water Resource and Protection*, 11(7), 844–851. <https://doi.org/10.4236/jwarp.2019.117051>
9. Abukmeil, R., Barhoum, A., Dher, M., & Yoshida, M. (2022). Assessment of health-care waste generation and its management strategy in the Gaza Strip, Palestine. *Journal of Material Cycles and Waste Management*, 24, 4–11. <https://doi.org/10.1007/s10163-021-01306-4>
10. AbuHamed, H., Al Bursh, W., Abu Mfarreh, S., Yoshida, M., & Jaber, A. (2023). Managing post-conflict demolition wastes in Gaza Strip: A case study on May 2021 conflict. *Journal of Material Cycles and Waste Management*, 25, 684–693. <https://doi.org/10.1007/s10163-022-01570-y>
11. Farhadi, N., Yarahmadi, A., & Afkhami, H. (2026). Infectious Diseases and Antimicrobial Resistance in the Gaza Strip: Epidemiological Drivers, Health System Disruptions, and Global Implications: A Narrative Review. *Health Science Reports*, 9(5), e72074.
12. Salem, H. S. (2025). The current Israeli war 2023–2025 on the Gaza Strip, Occupied Palestine, based on social, economic, public health, environmental, geopolitical, and human rights' perspectives. *Environmental Justice*. Advance online publication. <https://doi.org/10.1089/env.2025.1392465>
13. Abd Rabou, A. N., Yassin, M. M., Al-Agha, M. R., Ali, A. S., & Hamad, D. M. (2007d). Aspects of inhabitants' ecological knowledge on Wadi Gaza. *International Conference "Energy and Environmental Protection in Sustainable Development"*, Palestine Polytechnic University (PPU), May 8-10, 2007.
14. Abd Rabou, A. N., Yassin, M. M., Al-Agha, M. R., Fayyad, N. A., Al-Zain, B. F., Ali, A. S., & Hamad, D. M. (2007e). On the benefits provided by the wetland ecosystem of Wadi Gaza – Gaza Strip. *The 2nd International Engineering Conference on Construction and Development (IECCD-II)*, Islamic University of Gaza, September 3-4, 2007, 44–58.

15. Abd Rabou, A. N., Yassin, M. M., Sharif, F. A., Al-Agha, M. R., Abu Daher, K. S., Ali, A. S., & Hamad, D. M. (2008a). Inhabitants' knowledge on mosquito proliferation and control in the wetland ecosystem of Wadi Gaza, Gaza Strip, Palestine. *The Islamic University Journal (Series of Natural Studies and Engineering)*, 16(2), 41–61.
16. Abd Rabou, A. N., Yassin, M. M., Al-Agha, M. R., Madi, M. I., Al-Wali, M. M., Ali, A. S., & Hamad, D. M. (2008b). Notes on some common flora and its uses in Wadi Gaza, Gaza Strip. *The Islamic University Journal (Series of Natural Studies and Engineering)*, 16(1), 31–63.
17. Machlis, G. E., & Hanson, T. (2008). Warfare Ecology. *BioScience*, 58, 729–736.
18. Gaynor, K. M., Fiorella, K. J., Kurz, D. J., Gregory, G. H., Seto, K. L., Withey, L. S., & Brashares, J. S. (2016). War and wildlife: Linking armed conflict to conservation. *Frontiers in Ecology and the Environment*, 14(10), 533–542.
<https://doi.org/10.1002/fee.1433>
19. Hanson, T. (2018). Biodiversity conservation and armed conflict: A warfare ecology perspective. *Annals of the New York Academy of Sciences*, 1429(1), 50–65.
<https://doi.org/10.1111/nyas.13689>
20. Sundaram, M., Filion, A., Akaribo, B. E., & Stephens, P. R. (2023). Footprint of war: Integrating armed conflicts in disease ecology. *Trends in Parasitology*, 39(4), 238–241.
<https://doi.org/10.1016/j.pt.2023.01.007>
21. Abd Rabou, A. N. (2005). *An ecological survey and assessment of Wadi Gaza Nature Reserve, Gaza Strip – Palestine, with particular emphasis on wildlife* [Doctoral dissertation, Al-Neelain University].
22. Yassin, M. M., Abd Rabou, A. N., & Al-Agha, M. R. (2006). Preliminary survey of terrestrial vertebrate fauna and people's awareness towards wildlife in the Northern Governorate of the Gaza Strip. *Al-Azhar Bulletin of Science: Zoology & Botany*, 17(1), 17–41.
23. Abd Rabou, A. N., Yassin, M. M., Al-Agha, M. R., Hamad, D. M., & Ali, A. S. (2007a). The avifauna of Wadi Gaza Nature Reserve, Gaza Strip - Palestine. *The Islamic University Journal (Series of Natural Studies and Engineering)*, 15(1), 39–85.
24. Abd Rabou, A. N., Yassin, M. M., Al-Agha, M. R., Hamad, D. M., & Ali, A. S. (2007b). The herpetofauna of the Gaza Strip with particular emphasis on the vicinity of Wadi Gaza. *The Islamic University Journal (Series of Natural Studies and Engineering)*, 15(1), 111–135.
25. Abd Rabou, A. N., Yassin, M. M., Al-Agha, M. R., Hamad, D. M., & Ali, A. S. (2007c). Wild mammals in the Gaza Strip, with particular reference to Wadi Gaza. *The Islamic University Journal (Series of Natural Studies and Engineering)*, 15(1), 87–109.
26. Abd Rabou, A. N., Al-Harazeen, H. R., Khogali, F. A., Rabaa, F. M., Hamad, D. M., Ali, A. S., Khalaf, N. A., Almeshal, W. I., Abd Rabou, M. A., Abd Rabou, O. A., Abd Rabou, A. A., Alkord, E. S., Al-Sweirki, S. H., Radwan, E. S., Al-Hali, D. I., Madkour, H. A., Madkour, F. A., & Mohamed, W. F. (2022). Notes on the non-flying mammalian fauna characterizing both sides of the Green Line; the de facto border between the Gaza Strip and historic Palestine. *Israa University Journal of Applied Science (IUGAS)*, 6(1), 191–227.
27. Abd Rabou, A. N. (2009). On the occurrence of some carnivores in the Gaza Strip, Palestine (Mammalia: Carnivora). *Zoology in the Middle East*, 46, 109–112.
28. Abd Rabou, A. N. (2019e). The mammalian, reptilian and amphibian fauna of Al-Mawasi ecosystem, south-western Gaza Strip – Palestine. *Agricultural Research & Technology: Open Access Journal*, 23(1), 301–314.
29. Abd Rabou, A. N. (2011b). Notes on some Palestinian bird fauna existing in the zoological gardens of the Gaza Strip. *American-Eurasian Journal of Agricultural & Environmental Sciences (AEJAES)*, 11(2), 159–172.
30. Abd Rabou, A. N. (2011c). The Palestinian mammalian fauna acquired by the zoological gardens in the Gaza Strip. *Nusantara Bioscience*, 3(2), 92–101.
31. Abd Rabou, A. N., Musallam, N. J., Musallam, E. J., Elkahlout, K. E., Elnabris, K. J., El-Bashiti, T. A., Abdel Aziz, I. I., Ishneiwa, R. M., Radwan, E. S., Saada, H. S., Shafei, A. A., Fayyad, N. A., Mwafy, S. N., Abu Amra, H. E., Abu Al-Ajeen, R. A., Abu Owda, M. F., Alfarra, R. N., Hassouna, H. A., Hassouna, R. A., Al-Agha, M. R., & Abd Rabou, M. A. (2020). The Palestinian terrestrial vertebrate fauna preserved at the biology exhibitions of the universities of the Gaza Strip. *Research in Ecology*, 2(4), 9–21.
32. Abd Rabou, A. N., El-Kichaoui, A. Y., El-Bashiti, T. A., Abdel Aziz, I. I., Elnabris, K. J., Aliwaini, S. H., Abed, A. A., Elkahlout, K. E., Abu-Jadallah, S. Y., Almahhouh, F. A., Alattar, E. M., Fayyad, N. A., Shafei, A. A., El-Hindi, M. W., Al-Sweirki, S. H., Alkhalidi, S. L., Bakheet, B. A., Abu Toima, R. M., Ashour, L. Z., Qaraman, A. W., Abu Amra, H. E., Aziz, A. Y., Rifi, M. M., Benmessaoud, R. M., Cherif, M. M., Abd Rabou, O. A., Abd Rabou, A. A., Abd Rabou, O. A., Khalaf, N. A., Salah, J. Y., Aboutair, M. A., Awadallah, S. M., Saqallah, W. M., Al-Agha, M. R., Shabat, M. M., & Jadallah, R. I. (2025). On the mummified marine and terrestrial vertebrate fauna adorning the Biology Department Museum at the Islamic University of Gaza, Gaza Strip, Palestine, before the Israeli war on October 7, 2023. *Open Journal of Ecology (OJE)*, 15(9), 528–568.
33. Meerburg, B. G., Singleton, G. R., & Kijlstra, A. (2014). Rodent-borne diseases and their risks for public health in changing environments. *Journal of Infection and Public Health*, 7(3), 161–170.
34. Himsworth, C. G., Parsons, K. L., Jardine, C., & Patrick, D. M. (2013). Rats, cities, people, and pathogens: A systematic review and narrative synthesis of literature regarding the ecology of rat-associated zoonoses in urban centers. *Vector-Borne and Zoonotic Diseases*, 13(6), 349–359.
<https://doi.org/10.1089/vbz.2012.1195>
35. Feng, A. Y. T., & Himsworth, C. G. (2014). The secret life of the city rat: A review of the ecology of urban Norway and black rats. *Urban Ecosystems*, 17, 149–162.
36. Rabiee, M. H., Mahmoudi, A., Siaharsvie, R., Kryštufek, B., & Mostafavi, E. (2018). Rodent-borne diseases and their public health importance in Iran. *PLOS Neglected Tropical Diseases*, 12(4), Article e0006256.
<https://doi.org/10.1371/journal.pntd.0006256>
37. Strand, T. M., & Lundkvist, Å. (2019). Rat-borne diseases at the horizon: A systematic review on infectious agents carried by rats in Europe 1995–2016. *Infection Ecology & Epidemiology*, 9(1), 1553461.
<https://doi.org/10.1080/20008686.2018.1553461>
38. UNEP – United Nations Environment Programme. (2024). *Environmental impact of the conflict in Gaza: Preliminary assessment of environmental impacts*. United Nations Environment Programme. ISBN: 978-92-807-4163-6.
39. Reuters. (2026). Rats infest Gaza's tent camps, biting children and spreading disease. *Reuters*.
<https://www.reuters.com/world/middle-east/rats-infest-gazas-tent-camps-biting-children-spreading-disease-2026-04-30/>
40. Mahase, E. (2026). Gaza: 1000 people killed since ceasefire as summer brings rodents and insects carrying disease. *The BMJ*, 393, e100026.
<https://doi.org/10.1136/bmj-2026-100026>
41. Dardona, Z., & Boussaa, S. (2025). Insect and Mice Infestations in Gaza Displacement Camps: A Field-Based Study on Vector-Borne Diseases Amid the 2023–2025 Gaza War. *Public Health Challenges*, 4(4), e70127.
42. United Nations. (2025). Plague of rats and insects provides latest challenge for war shattered Gazans. *Peace and Security News*. <https://news.un.org/en/story/2025/04/1162726>

43. Plaza, P. I., Blanco, G., & Lambertucci, S. A. (2020). Implications of bacterial, viral and mycotic microorganisms in vultures for wildlife conservation, ecosystem services and public health. *Ibis*, 162(4), 1109–1124. <https://doi.org/10.1111/ibi.12865>
44. Plaza, P. I., Blanco, G., Madariaga, M. J., Boeri, E., Teijeiro, M. L., Bianco, G., & Lambertucci, S. A. (2019). Scavenger birds exploiting rubbish dumps: Pathogens at the gates. *Transboundary and Emerging Diseases*, 66(2), 873–881. <https://doi.org/10.1111/tbed.13097>
45. Han, B. A., Schmidt, J. P., Bowden, S. E., & Drake, J. M. (2015). Rodent reservoirs of future zoonotic diseases. *Proceedings of the National Academy of Sciences of the United States of America*, 112(22), 7039–7044. <https://doi.org/10.1073/pnas.1501598112>
46. Sphere Association. (2018). *The Sphere handbook: Humanitarian Charter and Minimum Standards in Humanitarian Response* (4th ed.). Sphere Association. <https://doi.org/10.3362/9781908176646>
47. Abd Rabou, A. N. (2019a). On the occurrence and health risks of the venomous Palestine Viper (*Vipera palaestinae* Werner, 1938) in the Gaza Strip – Palestine. *Biomedical Journal of Scientific & Technical Research*, 18(5), 13934–13937.
48. Abd Rabou, A. N. (2024). On the Palestinian reptilian fauna caged and/or kept stuffed at zoos of the Gaza Strip. *Open Journal of Ecology (OJE)*, 14(12), 950–980.
49. Gutiérrez, J. M., Calvete, J. J., Habib, A. G., Harrison, R. A., Williams, D. J., & Warrell, D. A. (2017). Snakebite envenoming. *Nature Reviews Disease Primers*, 3, 17063. <https://doi.org/10.1038/nrdp.2017.63>
50. Gutiérrez, J. M., Casewell, N. R., & Laustsen, A. H. (2025). Progress and challenges in the field of snakebite envenoming therapeutics. *Annual Review of Pharmacology and Toxicology*, 65, 465–485. <https://doi.org/10.1146/annurev-pharmtox-022024-033544>
51. Dardona, Z., Amame, M., Dardona, A., & Boussaa, S. (2024a). House flies and their role in transmitting infectious diseases: Focusing on parasitic infectious diseases. *Revue Des Sciences Infirmières Et Techniques De Santé*, 3(1), 55–72.
52. Dardona, Z., Amame, S., & Boussaa, S. (2024b). Assessing the epidemiological status and awareness level of hepatitis A virus among displaced populations in southern Gaza during the 2023–2024 conflict. *Microbes and Infectious Diseases*. <https://doi.org/10.21608/mid.2024.305028.2087>
53. Dardona, Z., Amame, M., & Boussaa, S. (2024c). Top five infectious disease outbreaks among displaced populations during the Gaza conflict 2023–2024: A comprehensive review. *Journal of Infectious Diseases and Epidemiology*, 10(9), 328.
54. Dardona, Z., Amame, M., & Boussaa, S. (2024d). Polio in Gaza: Another disastrous outcome of the Gaza conflict, 2023–2024. *Asian Pacific Journal of Tropical Medicine*, 17(9), 381–383.
55. Dardona, Z., Amame, M., Dardona, A., & Boussaa, S. (2025a). Health and environmental impacts of Gaza conflict (2023–2024): A review. *One Health Bulletin*, 5(1), 1–12.
56. Dardona, Z., Amame, M., & Boussaa, S. (2025b). Scabies and lice infestations in Gaza: Risk factors and public health challenges during the 2023–2024 conflict. *Egyptian Journal of Dermatology and Venerology*, 45(2), 127–133.
57. Bitam, I., Dittmar, K., Parola, P., Whiting, M. F., & Raoult, D. (2010). Fleas and flea-borne diseases. *International Journal of Infectious Diseases*, 14(8), e667–e676.
58. Brook, I. (2024). Mosquito-borne diseases: Current overview and their impact on children. *International Journal of Clinical Pediatrics*, 13(3), 67–68.
59. Destoumieux-Garzón, D., Mavingui, P., Boetsch, G., Boissier, J., Darriet, F., Duboz, P., Fritsch, C., Giraudoux, P., Le Roux, F., Morand, S., Paillard, C., Pontier, D., Sueur, C., Voituron, Y., & the One Health Research Group. (2018). The One Health Concept: 10 Years Old and a Long Road Ahead. *Frontiers in Veterinary Science*, 5, Article 14. <https://doi.org/10.3389/fvets.2018.00014>
60. UNRWA – United Nations Relief and Works Agency for Palestine Refugees in the Near East. (2025). *Gaza emergency situation reports*. UNRWA.
61. McFarlane, R., Sleigh, A. C., & McMichael, C. (2012). Synanthropy of wild animals in urban environments and implications for disease emergence. *EcoHealth*, 9(1), 1–10. <https://doi.org/10.1007/s10393-011-0728-3>
62. Moya, M. M., Gutiérrez, M. C., Hernández, J. M., López, R. A., & Sánchez, P. R. (2019). Urban ecosystem disturbance and synanthropic wildlife dynamics in humanitarian crises. *Urban Ecosystems*, 22, 1023–1035. <https://doi.org/10.1007/s11252-018-0824-9>
63. Gutkowski, N. (2021). Bodies that count: Administering multispecies in Palestine/Israel's borderlands. *Environment and Planning E: Nature and Space*, 4(1), 135–157.
64. Abushbak, A. M., & Majeed, T. (2026). Beyond human subjects: Reporting non-human war victims in Gaza. *The Communication Review*, 1–24.
65. Panti-May, J. A., Carvalho-Pereira, T. S. A., Serrano, S., Firth, C., Nunes, B. T., Minter, A., Aires, C. C. M., Saldanha, A. C. R., & Costa, F. (2017). Zoonotic transmission of pathogens by synanthropic rodents in urban environments. *Revista do Instituto de Medicina Tropical de São Paulo*, 59, e64. <https://doi.org/10.1590/S1678-9946201759064>
66. Kibret, F. (2010). *Environmental health conditions and associated health threats in Kebribeyah refugee camp, Somali National Regional State, eastern Ethiopia* [Doctoral dissertation, Addis Ababa University]. Addis Ababa University Institutional Repository. <https://etd.aau.edu.et/handle/123456789/11024>
67. Davis, S., Begon, M., De Bruyn, L., Gottdenker, N., & Dubynskiy, V. M. (2004). Predictive thresholds for plague in Kazakhstan. *Science*, 304(5671), 736–738. <https://doi.org/10.1126/science.1091006>
68. Himsworth, C. G., Parsons, K. L., Jardine, C., & Patrick, D. M. (2015). Rats, cities, people, and pathogens revisited: Updated perspectives on rodent-borne disease risks. *Vector-Borne and Zoonotic Diseases*, 15(6), 350–359. <https://doi.org/10.1089/vbz.2014.1749>
69. Yiğit, N., Özeren, S. C., Yiğit, F. S., Çolak, E., Gül, N., & Çetintürk, D. (2021). Alien Vertebrates and Vertebrate Pests in Turkey with an Overview of Rodent Management. *Journal of Scientific Reports-A*, (046), 59–80.
70. El-Kichaoi, A. Y., Abd Rabou, A. N., Sharif, F. A., & Al-Amassi, H. M. (2004). Changing trends in frequency of intestinal parasites in Gaza Strip, 1995 - 2000. *Journal of the Islamic University of Gaza (Natural Sciences Series)*, 12(2), 121–129.
71. Eisen, R. J., & Gage, K. L. (2012). Transmission of flea-borne zoonotic agents. *Annual Review of Entomology*, 57(1), 61–82.
72. Digne, C., Ballesteros-Mejia, L., & Cuthbert, R. N. (2023). Economic costs of invasive rodents worldwide: The tip of the iceberg. *PeerJ*, 11, Article e14935. <https://doi.org/10.7717/peerj.14935>
73. Okoli, C. E., Habeeb, I. O., & Pilau, N. N. (2024). An assessment of the impact of rodent infestations on public health in Abuja Municipal Area Council (A.M.A.C), Nigeria. *Journal of Research in Forestry, Wildlife and Environment*, 16(3), 105–115. <https://www.ajol.info/index.php/jrfwe/article/view/281795>
74. Al-Hindi, A. I., & Abu-Haddaf, E. (2013). Gastrointestinal parasites and ectoparasites biodiversity of *Rattus rattus* trapped from Khan Younis and Jabalia in Gaza Strip, Palestine. *Journal of the Egyptian Society of Parasitology*, 43(1), 259–268.

75. Al-Hindi, A. I., Meqdad, B., & Kishta, R. (2021). Occurrence of intestinal parasitic diseases of mice *Mus musculus* in Gaza and Rafah, Gaza Strip, Palestine. *Munis Entomology & Zoology*, 16(1), 268–274.
76. Farrell, S., McGarry, J., & Noble, P. J. (2023). Seasonality and other risk factors for fleas infestations in domestic dogs and cats. *Medical and Veterinary Entomology*, 37(2), 359–370.
77. Braverman, I. (2026). Zoometrics and the Dogs of Gaza: Species, Race, and Settler-Colonial Violence. *Theory & Event*, 29(2), 347–375.
78. Abu-Hasan, N., Daragmeh, M., Adwan, K., Al-Qaoud, K., & Abdel-Hafez, S. (2002). Human cystic echinococcosis in the West Bank of Palestine: Surgical incidence and seroepidemiological study. *Parasitology Research*, 88(2), 107–112.
79. Al-Jawabreh, A., Dumaidi, K., Ereqat, S., Nasereddin, A., Al-Jawabreh, H., Azmi, K., ... Abdeen, Z. (2015). Incidence of *Echinococcus granulosus* in domestic dogs in Palestine as revealed by copro-PCR. *PLOS Neglected Tropical Diseases*, 9(7), e0003934. <https://doi.org/10.1371/journal.pntd.0003934>
80. Al-Hindi, A. I., Abu-Draz, M., El-Zenati, A., Ali, A. A., & Dagga, A. A. (2019). Occurrence of Toxoplasmosis and other intestinal parasites among stray cats in Khanyounis Governorate, Palestine. *IUG Journal of Natural Studies*, 27(2), 29–35. <https://journals.iugaza.edu.ps/index.php/IUGNS/article/view/6306>
81. Krauss, H., Weber, A., Appel, M., Enders, B., Schiefer, H. G., Hahn, H., Pfister, H., & Schönberg, A. (2016). *Zoonoses: Infectious diseases transmissible from animals to humans* (4th ed.). ASM Press.
82. Surkes, S. (2024). Feral dogs from Gaza enter Israel, compounding nature authority's war woes. *The Times of Israel* (February 13, 2024). <https://www.timesofisrael.com/feral-dogs-from-gaza-enter-israel-compounding-nature-authoritys-war-woes/>
83. Abd Rabou, A. N., Elkahlout, K. E., Almabhouh, F. A., Mohamed, W. F., Khalaf, N. A., Al-Sadek, M. A., Alfarra, R. N., Al-Moqayed, L. T., Shafei, A. A., Fayyad, N. A., Adeem, B. S., Dardona, A. W., Awad, A. S., Al-Agha, M. R., & Abd Rabou, M. A. (2021). Occurrence and some ecological aspects of the Golden Jackal (*Canis aureus* Linnaeus, 1758) in the Gaza Strip, Palestine. *Open Journal of Ecology (OJE)*, 11(2), 105–125.
84. Abd Rabou, A. N., Al-Harazeen, H. R., Abu Alajeen, R. A., Rafeea, A. A., Al-Sweirki, S. H., Hassouna, H. A., Abd Rabou, A. A., Madkour, F. A., Madkour, H. A., Abd Rabou, M. A., Al-Dalou, M. F., Abu Amra, H. E., Abd Rabou, O. A., Al-Hali, D. I., & Khalaf, N. A. (2025). Spotlights on a Desert Lynx (*Caracal caracal* Schreber, 1776) attacking Israeli soldiers in the Negev Desert, Palestine. *Journal of Entomology and Zoology Studies*, 13(3), 5–13.
85. The Times of Israel. (2026). 'Her whole face was covered in blood': 11 campers attacked by jackals at Sea of Galilee (June 13, 2026). *The Times of Israel*. <https://www.timesofisrael.com/her-whole-face-was-covered-in-blood-11-campers-attacked-by-jackals-at-sea-of-galilee/>
86. Abd Rabou, A. F. N. (2023). Concerns associated with the sporadic occurrence of the Arabian wolf (*Canis lupus* Linnaeus, 1758) in the eastern Gaza Strip–Palestine. *International Journal of Fauna and Biological Studies*, 10, 7–18.
87. Baker, M. A. A., Al-Saraireh, M., Amr, Z., Amr, S. S., & Warrell, D. A. (2022). Snakebites in Jordan: A clinical and epidemiological study. *Toxicon*, 208, 18–30.
88. Albaba, I. (2017). Venomous snakes and envenomation in Palestine. *Journal of Entomology and Zoology Studies*, 5(2), 493–495.
89. Nowak, E. M., Theimer, T. C., & Schuett, G. W. (2008). Functional and numerical responses of predators: Where do vipers fit in the traditional paradigms? *Biological Reviews*, 83(4), 601–619. <https://doi.org/10.1111/j.1469-185X.2008.00056.x>
90. O'Bryan, C. J., Brackowski, A. R., Beyer, H. L., Carter, N. H., Watson, J. E. M., & McDonald-Madden, E. (2018). The contribution of predators and scavengers to human well-being. *Nature Ecology & Evolution*, 2, 229–236. <https://doi.org/10.1038/s41559-017-0421-2>
91. DeVault, T. L., Rhodes, O. E., Jr., & Shivik, J. A. (2003). Scavenging by vertebrates: Behavioral, ecological, and evolutionary perspectives on an important energy transfer pathway in terrestrial ecosystems. *Oikos*, 102(2), 225–234. <https://doi.org/10.1034/j.1600-0706.2003.12378.x>
92. Inger, R., Cox, D. T. C., Per, E., Norton, B. A., & Gaston, K. J. (2016). Ecological role of vertebrate scavengers in urban ecosystems in the UK. *Ecology and Evolution*, 6(19), 7015–7023. <https://doi.org/10.1002/ece3.2414>
93. Abd Rabou, A. N. (2019b). Bird fauna encountered at the main campus of the Islamic University of Gaza, Gaza City – Palestine. *Biodiversitas*, 20(2), 604–614.
94. Abd Rabou, A. N. (2019d). Ornithofauna prevailing at Al-Mawasi ecosystem of the Gaza Strip, Palestine. *Open Journal of Ecology (OJE)*, 9(9), 360–400.
95. Abd Rabou, A. N., & Abd Rabou, M. A. (2019). Notes on the pigeons and doves (Family Columbidae) occurring in the Gaza Strip – Palestine. *Jordan Journal of Natural History (JJNH)*, 6(1), 30–38.
96. Abd Rabou, A. N., Jarayseh, B. S., Sirdah, L. M., Sirdah, M. M., Ababsa, S. A., Al-Hali, D. I., Dardona, A. W., Shafei, A. A., Fayyad, N. A., Awad, A. S., Almeshal, W. I., Abuzerr, S. S., Abd Rabou, I. A., Abd Rabou, O. A., Abd Rabou, M. A., Abu Sharekh, S. A., Al-Agha, M. R., Yassin, M. M., Hammad, A. I., Khalaf, N. A., & Mohamed, W. F. (2023). Checklist of the Birds of the Gaza Strip – Palestine. *Open Journal of Ecology (OJE)*, 13(3), 155–182.
97. Abd Rabou, A. N., Alashqar, O. J., Al-Agha, M. R., Qaraman, A. A., Khalaf, N. A., Rouqa, D. J., Al-Shomali, S. L., Al-Hali, D. I., Abu-Laymon, S. M., Rashid, H. R., Al-Shaibei, M. S., Musa, B. I., Dawwas, W. M., Marie, R. K., Ababsa, S. I., Jadallah, R. I., Amodi, E. A., Abd Rabou, O. A., Shaladan, R. A., Abd Rabou, A. A., Abd Rabou, M. A., Abd Rabou, O. A., Abu Toima, R. M., Ashour, L. Z., Mohanna, A. M., Rafeea, A. A., Elnabaheen, E. M., Gafar, M. F., Abd Rabou, N. F., Abu Shammala, A. A., Abu Sabha, S. M., & Shabat, M. M. (2025). On the birds adorning the courtyards of the blessed Al-Aqsa Mosque in Al-Quds (Jerusalem), Palestine, with a special focus on Rock and Feral Pigeons. *Open Journal of Ecology (OJE)*, 15(8), 467–499.
98. Abd Rabou, A. N. (2022). On the occurrence, trapping and potential risks of the invasive Indian Myna (*Acridotheres tristis* Linnaeus, 1766) in the Gaza Strip: Palestine. *International Journal of Fauna and Biological Studies*, 9(5), 45–55.
99. OCHA – United Nations Office for the Coordination of Humanitarian Affairs. (2026). *Humanitarian situation reports and displacement-site assessments: Gaza Strip*. Occupied Palestinian Territory: OCHA / UN Office for the Coordination of Humanitarian Affairs. <https://www.unocha.org/occupied-palestinian-territory>
100. Hopkins, W. A. (2007). Amphibians as models for studying environmental change. *ILAR Journal*, 48(3), 270–277.
101. Olagunju, E. A. (2023). Is the presence of mosquitoes an indicator of poor environmental sanitation? *Journal of Water and Health*, 21(3), 385–401.
102. Blaustein, A. R., Han, B. A., Relyea, R. A., Johnson, P. T. J., Buck, J. C., Gervasi, S. S., & Kats, L. B. (2011). The complexity of amphibian population declines: Understanding the role of multiple stressors. *Frontiers in Ecology and the Environment*, 9(3), 161–170.

103. Grant, E. H. C., Miller, D. A. W., Schmidt, B. R., Adams, M. J., Amburgey, S. M., et al. (2016). Quantitative evidence for the effects of multiple drivers on continental-scale amphibian declines. *Scientific Reports*, 6, 25625.
104. Murray, M. H., Byers, K. A., & Buckley, J. Y. (2024). Associations between rat infestations and mental health vary by gender, race, and income in Chicago. *Journal of Urban Health*, 101(2), 318–326.
105. Zaydah, H. Y. A. (2025). Living through the war in Gaza: An autoethnographic account of psychological, humanitarian, and physical suffering of Gaza's inhabitants during the war in Gaza. *Torture Journal*, 35(2-3), 28–49.
106. Hassan, A. S. M., Barakat, A. H. H., Abudayya, D. M. H., Abulkhair, L. M. S., Abu Amra, M. A. A. R. S., Abdullateif, N. N. E., Owais, T. A., Sabbah, M., Suliman, J., Warasna, H. J. M., Awad, M. Y. H., & Abu Serriya, R. A. A. (2026). A cross-sectional study of the burden and risk factors of impetigo and scabies among children during conflict in the middle area of the Gaza Strip. *Scientific Reports*, 16(1), 8422. <https://doi.org/10.1038/s41598-026-38441-7>
107. Hulme, K. (2022). Using international environmental law to enhance biodiversity and nature conservation during armed conflict. *Journal of International Criminal Justice*, 20(5), 1155–1190. <https://doi.org/10.1093/jicj/mqac060>
108. Rintoul-Hynes, N. L. (2025). Environmental considerations for post-war reconstruction of Gaza. *Ambio*, 54(11), 1979–1984.