

Vol IV, No 3, 2026

 WESTERN
cas pian UNIVERSITY

e-ISSN 3005-9070
p-ISSN 3005-9062

JOURNAL OF ENDEMISM: *biodiversity & environment*

JOURNAL OF

ENDEMISM:

biodiversity & environment

Vol IV, No 3
September, 2026

 Western Caspian University

BAKU-2026



WESTERN
cas p ian UNIVERSITY

Western Caspian University

E-ISSN: 3005-9070

P- ISSN:3005-9062

**Journal of Endemism:
biodiversity & environment
Vol IV, No 3
September 2026**

DOI:10.54414/UPXH5896



© Western Caspian University, 2026

www.ebe.wcu.edu.az

Editorial Board

Editor-in-Chief

Husseyin Baghirov

Prof., Western Caspian University, Azerbaijan

Editorial Board:

Ahmet Ipek

Prof., Uludag University, Türkiye

Sezai Ercisli

Prof., Ataturk University, Türkiye

Han Jianlin

Dr., International Livestock Research Institute, China

Nguyen Van Tiep

Prof., Joint Institute for Nuclear Research, Russia

Ismail Turkan

Prof., Ege University, Türkiye

David Bedoshvili

Dr., Georgian State Agricultural University, Georgia

Marco Maccaferri

Prof., University of Bologna, Italy

Nevena Alexandrova

Dr., FAO, Rome, Italy

Cristobal Uauy

Prof., John Innes Centre, United Kingdom

Yaroslav Blume

Prof., Institute of Food Biotechnology and Genomics,
Ukraine

Zeliha Selamoglu

Prof., Niğde Ömer Halisdemir University, Türkiye

Firuza Nasyrova

Prof., Tajikistan Botanical Institute, Tajikistan

Ram Chandra Sharma

Dr., ICARDA, Uzbekistan

Zafar Ziyaev

Dr., Plant Institute, Uzbekistan

Mikael Sukkov

Dr., Natural Heritage Foundation, Germany

Matlab Mirzayev

Prof., Joint Institute for Nuclear Research, Russia

Florian Rupp

Prof., Kutaisi International University, Georgia

Ilham Shahmuradov

Prof., Institute of Biotechnology and Molecular Biology,
Azerbaijan

Mehraj Abbasov

Assoc.Prof., Institute of Genetic Resources, Azerbaijan

Naila Guliyeva

Dr., Western Caspian University

Saltanat Aghayeva

Dr., Western Caspian University

Ayaz Mammadov

Dr., Western Caspian University

CONTENTS

DOI: 10.54414/MEPW2002

CURRENT STATE OF FOREST ECOSYSTEMS IN THE NORTHEASTERN PART OF THE GREATER CAUCASUS

Elman Isgandar, Minara Hasanova, Ilhama Mircalalli, Nigar Badalzada, Shabnam Hajiyeva, Seyfaddin Taghiyev, Sadaqat Aliyeva

4

DIVERSITY OF GAZELLE SPECIES BELONGING TO THE GENUS *GAZELLA* AND MEASURES FOR THEIR CONSERVATION

Khalida Muradli, Konul Ahmadova, Badriye Ahmadova

11

MICROBIOLOGICAL FEATURES AND MECHANISMS OF ANTIBIOTIC RESISTANCE OF BIOFILM FORMATION IN BACTERIA OF CLINICAL ORIGIN

Lamiya Jeyhun Khalilzada, Aygun Samad Suleymanova

25

STABILITY OF POTASSIUM AND LDH INDICATORS IN HEMOLYTIC AND LIPEMIC BLOOD SERUM

Fidan Mubarizsoy, Aygun Samad Suleymanova, Ayaz Israfilov, Namiq Iskandarov

30

ANTHROPOZOONOTIC DISEASES, DIAGNOSTICS AND TREATMENT METHODS

Sabina Elman Kazimli

39



CURRENT STATE OF FOREST ECOSYSTEMS IN THE NORTHEASTERN PART OF THE GREATER CAUCASUS

Elman Isgandar¹, Minara Hasanova¹, Ilhama Mircalalli¹, Nigar Badal-zada^{1*},
Shabnam Hajiyeve¹, Seyfaddin Taghiyev¹, Sadaqat Aliyeva¹

¹Institute of Botany, Ministry of Science and Education of the Republic of Azerbaijan, AZ1073, Baku, Azerbaijan

Abstract: The article covers the study of the Greater Caucasus mountains in the northern and northeastern parts of Azerbaijan. The research is dedicated to the analysis of the composition of the phytocoenosis, the anthropogenic factor, and the study of the impact of this factor on the forest flora. It has been determined that the forest vegetation of the area is of particular importance as a gene pool source for ensuring natural forest regeneration.

Keywords: Greater Caucasus, forest ecosystem, phytocoenosis, anthropogenic factor, flora.

*Corresponding author: nigarbadalzade@mail.ru

Received: 7 August 2026

Accepted: 18 August 2026

Published: 18 September 2026

DOI: 10.54414/SFBK4369

Introduction

The Greater Caucasus Mountains cover the northern and northeastern parts of Azerbaijan. The Greater Caucasus Range occupies the central part. To the north of the Greater Caucasus Range lies the Lateral Range; to the south, the Niyaldag and Govdag ranges; and to the southeast, the Langabiz and Gobustan low mountain areas, the Alat Ridge, and the Absheron Peninsula. The Gusar sloping plain and the Samur-Davachi lowland are located in the northeastern part of the Greater Caucasus physical-geographic region. All climate types are found in the province (except for the cold climate type with dry summers). The mean annual temperature ranges from 0°C to 14°C, and mean annual precipitation is 100–1400 mm. The rivers include left tributaries of the Kura (Turyanchay, Alijanchay, Goychay, Ayrychay, etc.) and

rivers that flow directly into the Caspian Sea (Samurchay, Gusarchay, Gudyalchay, etc.). The mountain lakes of the region contain fresh water, while the lowland lakes are saline. All of Azerbaijan's landscape types are found in the Greater Caucasus region. There are nature reserves in Zaqatala, Ilisu, Ismayilli, Pirqulu, Altiagac, and Qobustan.

Materials and Methods

The study was conducted in the northeastern part of the Greater Caucasus, Azerbaijan. The study area is characterized by diverse relief, altitudinal zones, and climatic conditions, which determine the structure and species composition of forest ecosystems.

Field investigations were carried out using route-based observations and ecological monitoring. The floristic

composition, distribution, and abundance of tree, shrub, and herbaceous species were recorded. Dominant, subdominant, rare, and protected plant species were identified based on morphological characteristics and relevant floristic literature.

The vertical structure of forest communities was assessed by distinguishing three vegetation layers, the upper layer consisting mainly of trees 20–30 m high, the middle layer comprising trees and shrubs 2–7 m high, and the lower layer consisting predominantly of herbaceous plants.

The effects of climatic variability were evaluated using temperature, precipitation, seasonal moisture conditions, elevation, and slope exposure as the main environmental factors. Their potential influence on plant growth, regeneration, species distribution, and forest structure was assessed.

Anthropogenic impacts were evaluated through field observations of tree cutting, forest thinning, soil disturbance, and other visible signs of human activity. The collected data were analyzed comparatively to assess changes in floristic composition, forest structure, natural regeneration, and the relationship between climatic and anthropogenic factors.

Results

The article examines the northern and northeastern parts of Azerbaijan and the Greater Caucasus. The study focuses on analyzing the composition of phytocoenoses and investigating the anthropogenic factor and its impact on forest flora. It is established that the forest vegetation of this territory is of particular importance as a gene pool source ensuring natural forest regeneration.

Discussion

It is well known that the existing forest vegetation type holds special significance as a gene pool source for ensuring natural

forest regeneration. The forest phytocoenosis holds great biocenotic significance because, by occupying a specific area, it creates an additional ecological niche for populations.

In this regard, the research attempts to evaluate forest-forming plants not only from an economic perspective (as a source of timber) but also from an ecological standpoint (considering forest protection functions, forest restoration, nutritional and aesthetic values, etc.) (Məmmədov & Xəlilov 2005).

It is well known that the forest ecosystem of the study area is of great importance from sanitary, hygienic, and social perspectives.

The most important hygienic characteristic of such an ecosystem lies in the creation of a microclimate that ensures normal external environmental conditions and the regulation of thermal and radiation effects. The importance of forest photosensors is well understood, given their role as a powerful factor in protecting the area from dust, gas, wind, and noise, as well as in soothing the human central nervous system. In general, the amount of dust in a forest area is two to three times lower than in open, non-forested areas. It should be noted that the dust-filtering role of forest areas also depends on the characteristics of the forest understory. Several researchers note that the absence of a normal grassy area in the forest understory significantly reduces dust deposition within the forest area. Active human economic activity necessitates the preservation of biodiversity and the implementation of monitoring systems, as well as active research into the flora of any given region. As far as we know, the damage to or clearing of forest areas in the study region is not determined by natural factors; it is primarily linked to anthropogenic factors.

These forests, which succeed one



another in a regular pattern according to altitudinal zones, are distinguished by their rare and valuable tree species. Unfortunately, during the initial years of crisis following the attainment of independence, these forests suffered from mass felling due to energy shortages; consequently, they became sparse, and their lower and upper boundaries receded significantly (Ковалев и др. 2024). Fortunately, however, significant progress has recently been made in supplying the population with natural gas in this region, as in all other parts of the Republic, leading to a substantial reduction in deforestation. Furthermore, considerable work is currently underway to establish new forest areas in the Greater Caucasus region, just as in other parts of the country.

However, we must regrettably note that the falling of valuable and rare tree species such as oak, walnut, chestnut, and beech, which are widely used in the construction and furniture industries, continues to this

day (Figure 1). We have investigated the anthropogenic impacts on the forest ecosystems of the northeastern part of the Greater Caucasus (within the territory of Azerbaijan), specifically examining the structure and dynamics of the forest phytocoenoses in the Khizi-Altiaghaj region, as well as the effects of climate variability and anthropogenic factors on plant development and forest ecosystems. Monitoring was conducted in the study area at an elevation of 1,100 m and geographic coordinates of 48°55' N, 37°06' E, with the primary objective of investigating the impact of climate variability and anthropogenic factors on the taxonomic composition of the vegetation. Based on monitoring results and literature data, work was carried out to characterize the forest area, 90.5% of which consists of broad-leaved forests, and to determine the taxonomic composition of the flora, dominant and subdominant species, as well as rare and endangered plant species.



Figure 1. The result of human activity

It is well known that the Altiaghaj forest consists largely of valuable tree species. Based on literature data and conducted monitoring, we have determined that mesophytes thrive on the slopes of the study area specifically on brown mountain forest soils and that the forest is primarily composed of species belonging to genera such as *Acer* L., *Quercus* L., *Populus* L., *Salix* L., *Ulmus* L., *Rhamnus* L., *Cornus* L., *Corylus* L., *Pyrus* L., *Cotinus* L. *Tamarix* L.,

Morus L., *Sambucus* L., *Pyracantha* Roem., *Rosa* L., *Rubus* L., *Euonymus* L., *Sorbus* L., *Carpinus* L., *Mespilus* L., *Fraxinus* L., *Betula* L., *Crataegus* L., *Paliurus* Mill., *Cotoneaster* Medic., and others (Əliyev 2020).

Species belonging to the mentioned genera form distinct plant communities and play a direct role in the formation of mountain-xerophytic vegetation. Thus, in the forest ecosystem we studied, the

conditions of the area where the plants are distributed vary in several respects (**Figure 2**).

The composition and age of the trees

and shrubs that make up the forest, as well as the forest's density, depend on the amount of sunlight, that is, the level of light that reaches them (Желдак и др. 2023).

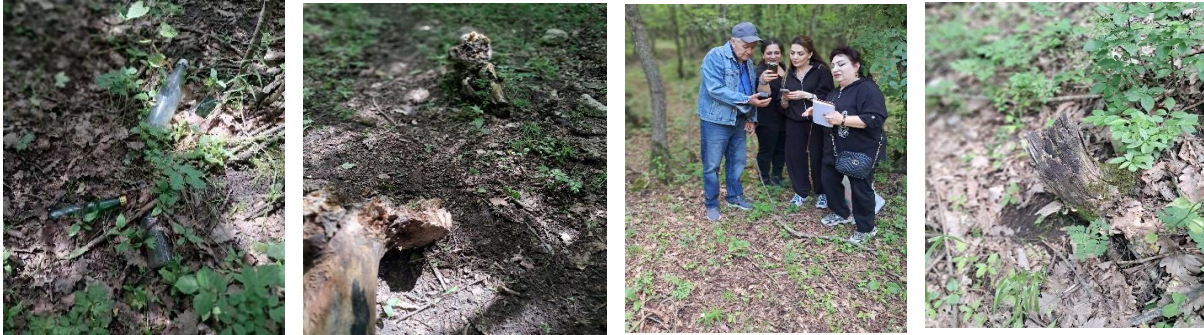


Figure 2: In the study area.

Depending on the level of illumination, the development of species with varying degrees of shade tolerance and a low rate of natural regeneration has been observed in the lower strata of the forest. The seasons have influenced the structural composition and species richness of the flora in the study area; specifically, we observed that ephemeral plants beneath the tree and shrub canopies develop rapidly in early spring—reaching the flowering stage before the trees become fully leafed out while the growing season of certain winter and typical (typical mesophyte) ephemeral species concludes (**Figure 3**). Such plants were not encountered in the vicinity of juniper species, as ephemerals could not develop under shaded conditions. The prevailing climate types in the Khizi-Altiaghaj study area are temperate-warm with dry winters and temperate-warm with dry summers. Plant species found in mountain forests, mountain meadows, semi-desert, and forest-steppe areas: Caucasian hornbeam (*Carpinus caucasica* Grossh.), ash.

Fraxinus excelsior L., Oriental beech (*Fagus orientalis* Lipsky), medlar (*Mespilus germanica* L.), barberry (*Berberis vulgaris* L.), hawthorn (*Crataegus pentagyna* Willd.), wayfaring tree (*Viburnum lantana* M.B.),

feathery asparagus (*Asparagus setaceus* (Kunth) Jessop), broad-leaved spindle (*Euonymus latifolia* (L.) Mill.), goat-leaf honeysuckle (*Lonicera caprifolium* L.), warty spindle (*Euonymus verrucosus* (L.) Mill.), rowan (*Sorbus aucuparia* L.), spiny milk-vetch (*Astragalus pycnophyllus* Stev.), etc. We recorded and photographed species included in the "Red Book," such as juniper (*Juniperus foetidissima* Willd.), Caucasian violet (*Viola caucasica*), and sharp-lobed iris (*Iris acutiloba* C.A. Meyer).

In the areas studied, woody plants such as medlar (*Mespilus germanica* L.), hawthorn (*Crataegus* sp.), cherry plum (*Prunus divaricata* Ledeb.), and quince (*Cydonia oblonga* Mill.) were observed in the understory shrub layer.

Species belonging to genera such as *Paliurus* Mill., *Frangula* Mill., *Cotoneaster* (including *C. saxatilis*), *Corylus* L., *Spiraea* L., *Crataegus* L., *Rhus* L., *Acer* L., *Quercus* L., *Ulmus* L., and *Carpinus* L. were studied in the riparian area.

The objective of studying the forest types and phytocoenotic structure of the research area was to identify the species composition of tree and shrub plants (dominant and subdominant) distributed within the area's forest ecosystems, as well



as the forest types formed by these plants (Лабoxa 2018). We observed a three-tiered structure in the forests covering the region's mountain slopes, which are composed primarily of mixed broad-leaved tree species.

A large part of the study area (approximately 90%) is covered by forest

phytocoenoses formed by broad-leaved tree species. The first tier of the forest phytocoenosis consists of trees 20–30 meters tall; the second tier comprises trees and shrubs reaching heights of 2–7 meters; and the third tier consists of herbaceous plants.

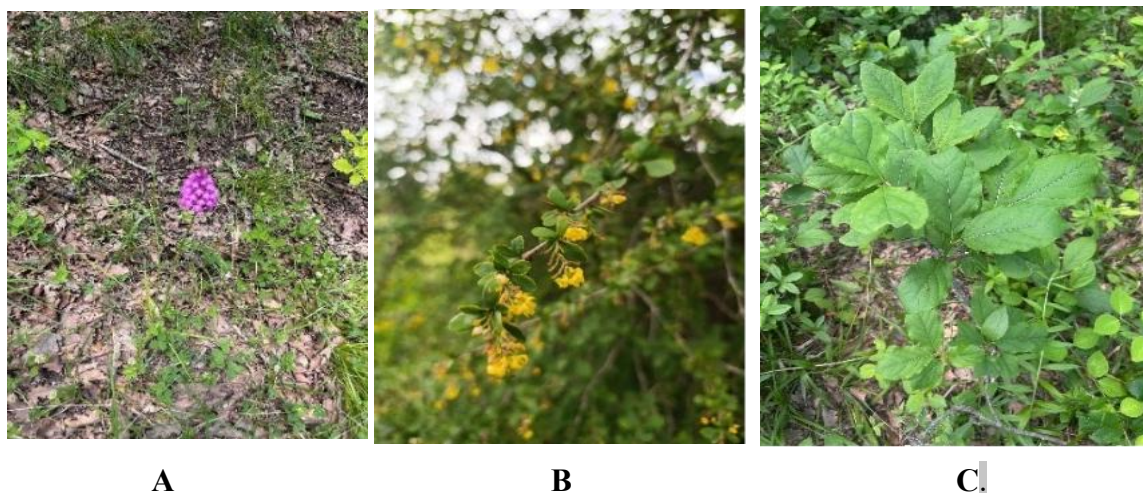


Figure 3. Some species of understory vegetation. **A.** *Tropaeolum majus* L.; **B.** *Berberis vulgaris* L.; **C.** *Euonymus latifolius* L.

The plants of the first tier of the forest phytocoenosis in the study area include *Quercus iberica* Steven ex M. Bieb., *Carpinus orientalis* Mill., *Fagus orientalis* L., *Fraxinus excelsior* L., *Acer platanoides* L., *A. laetum* C.A.Mey, and others (Өсгөрoв 2016).

The tree species mentioned above often form mixed forest phytocoenoses; in other words, forests of uniform composition are rarely encountered in the area. Shade-tolerant tree and shrub species predominate in mixed forest phytocoenoses; the soil cover in such forests is rich in humus, and humid microclimatic conditions develop beneath the forest canopy (Горбунов и др. 2020).

In the area, the vegetation of the second tier consists primarily of shrubs, such as *Crataegus* spp. *Rosa canina*, *Rubus* subg. *rubus*, *Mespilus germanica*, *Lonicera*

caprifolium, *Sorbus torminalis*, *Euonumus velutina*. Tree species such as *Pyrus communis*, *P. georgica*, *P. salicifolia*, and *P. vsevolodi* are also found in open forest clearings. Furthermore, perennial herbaceous plant species predominate in such open meadows. The forest type of the study area consists primarily of mixed deciduous trees. The species composition of the trees varies according to their altitudinal distribution. The forest cover of the Khizi-Altiaghaj region retains its natural state. It has been determined that the dominant species, Georgian oak and Caucasian hornbeam, maintain stable populations. However, thinning is observed at the edges of forests and in areas close to human settlements. In the Khizi-Altiaghaj region, the entry of livestock from surrounding villages into forest areas leads to the consumption of young saplings and the

destruction of shoots, thereby weakening the forest's capacity for natural regeneration. As a result, the forest is "aging" because a new generation to replace the old trees is not developing. However, in recent years, the process of natural forest regeneration has accelerated. The growth of naturally regenerating hornbeams and birch saplings has led to the rejuvenation of the forest. The development of oak and beech species is proceeding slowly.

The areas surrounding the Khizi-Altiaghach region, where the local population makes intensive use of the forest, are the ones under the greatest stress. Due to the numerous narrow paths and the resulting soil compaction, the understory vegetation (grasses and shrubs) is poorly developed. Observations revealed that in areas where fires had occurred, vegetation failed to regenerate for many years, or successional processes were noted in specific forest sections. We are investigating how rising temperatures resulting from climate change alter the phenology of trees, specifically their flowering, leafing, and budding periods, thereby making them more vulnerable to early frosts and pests, and how temperature variability directly affects radial growth dynamics, the process of photosynthesis, and root system development. Carving various inscriptions into the trunks of old beech and oak trees, or damaging them with an axe, reduces the tree's resistance to fungi and diseases.

This, in turn, results in the thinning of forest areas over time. Forest areas damaged by anthropogenic impact (due to fire, illegal logging, overgrazing, or hay mowing in clearings) recover within 2 to 5 years after the activity ceases, depending on the plant species and the severity of the damage. It takes 15–25 years for fast-growing trees (such as hornbeam, maple, etc.) to establish themselves in a forest ecosystem. It takes 50–80 years, or sometimes even a century,

for slow-growing, primary tree species (such as beech and oak) to form a fully developed forest canopy.

Conclusion

As a result of monitoring conducted in the Khizi-Altiaghach study area, the vegetation cover was partially surveyed, and we identified 120 plant species belonging to 54 genera and 36 families across various stages of plant development.

It has been determined that anthropogenic impact has caused damage to forest areas, and the rehabilitation of these areas—depending on the plant species and the extent of the damage—may span a period of years.

Conflict of Interest

The authors declare that there is no conflict of interest.

References

- Əsgərov A.M. (2016) Azərbaycanın bitki aləmi (Ali bitkilər - Embryophyta). Bakı: TEAS press nəşriyyat evi, 444 s.
- Əliyev F.Ə. (2020) Böyük Qafqazın cənub-şərq yamacında landşaftların inkişaf xüsusiyyətləri. Bakı: Elm nəşriyyatı, 127 s.
- Məmmədov Q.Ş., Xəlilov M.Y. (2005) Ekologiya və ətraf mühitin mühafizəsi Bakı: Elm nəşriyyatı, 880 s.
- Горбунов Р.В., Табунщик В.А., Горбунова Т.Ю. (2020) Нерешенные теоретические и методологические вопросы при эстетической оценке ландшафтов. *Географический вестник*, 3(54):6–22.
- Желдак В.И., Дорощенкова Э.В., Прока И.Ю., Сычева А.Н., Липкина Т.В. (2023) Вопросы лесоводственного совершенствования системы сохранения и использования лесов в



- рамках решения проблемы адаптации лесов и лесного комплекса к изменениям климата. *Лесохозяйственная информация*, 2: 5–26.
- Ковалев А.П., Алексеенко А.Ю., Качанова Т.Г. (2024) Лесоводственные принципы выбора способов технологий рубок в лесах Дальнего Востока. *Сибирский лесной журнал*, 5;96–102.
- Лабоха К.В. (2018) Лесоведение: учеб. Пособие для студентов учреждений высшего образования по специальности «Лесное озяйство». Минск: БГТУ, 264 с.



DIVERSITY OF GAZELLE SPECIES BELONGING TO THE GENUS *GAZELLA* AND MEASURES FOR THEIR CONSERVATION

Khalida Muradli^{1*}  , Konul Ahmadova¹ , Badriye Ahmadova²  

¹Department of Natural Sciences, Western Caspian University, AZ1072, Baku, Azerbaijan

²Baku Zoo, Nərimanov, Baku, Azerbaijan

Abstract: Gazelles possess a high capacity for adaptation to arid and semi-desert conditions. Their body structure, sense organs, modes of movement, seasonal coat changes, and water-conserving physiological mechanisms enable them to survive in a harsh environment. The behavior, seasonal movements, and feeding habits of gazelles are also important components of these adaptations. As an important component of Azerbaijan's natural fauna, they play a significant role in preserving biodiversity and ensuring the stability of semi-desert and steppe ecosystems. This article summarizes the biological, ecological, morphological, physiological, and behavioral characteristics of gazelles, as well as their distribution, habitat, diet, population dynamics, the threats they face, and conservation measures. Research indicates that gazelles have inhabited the territory of Azerbaijan since ancient times. However, since the mid-20th century, gazelle populations and their distribution have declined significantly due to illegal hunting, habitat loss, agricultural expansion, and other anthropogenic factors. The expansion of protected areas, population monitoring, reintroduction programs, and public awareness initiatives—both globally and in Azerbaijan—have had a positive impact on the recovery of gazelle populations. Thus, the long-term conservation of gazelles requires a comprehensive approach that integrates habitat protection, the prevention of illegal hunting, scientific monitoring, the restoration of ecological connections, and international cooperation. The ecological, historical, and cultural significance of gazelles makes their conservation a priority in the protection of biodiversity.

Keywords: biodiversity, distribution range, habitat, migration, population dynamics, ecological adaptation, anthropogenic factors, reintroduction.

*Corresponding author: muradlkhalida12@gmail.com

Received: 17 August 2026

Accepted: 31 August 2026

Published: 18 September 2026

DOI: 10.54414/EGNN8531

Introduction

The Antilopini include true gazelles (genera *Eudorcas*, *Gazella*, and *Nanger*), *Procapra* (which, like gazelles, differ from dwarf antelopes), *Saiga*, and dwarf antelopes (*Dorcatragus*, *Madoqua*, *Ourebia*, and

Raphicerus).

Gazelles are antelopes belonging to the genus *Gazella* and the order Artiodactyla. There are also seven species belonging to the genera *Eudorcas* and *Nanger*, which

were previously considered subgenera of the genus *Gazella*. The third subgenus, *Procapra*, comprises three extant species of Asian gazelles.

Taxonomically, antelopes belong to subclass Theria, Superorder Eutheria (Placenta), Order Artiodactyla, Suborder Ruminantia, Family Bovidae, Subfamily Antilopinae, and tribe Antilopini (Castelló 2016).

Gazelles are divided into three genera and numerous species (Khaleel & Salih 2017). According to Lydekker's catalogue, numerous forms of gazelles include 27 species (Blank 2025). It is found in Miocene, Pliocene, and Pleistocene deposits across Eurasia and Africa, indicating a wider distribution than that of the genus's modern members. The earliest members of the genus are known from the Middle Miocene of Africa (approximately 14 million years ago), and members of the genus lived in Europe from the Late Miocene until their extinction during the Early Pleistocene, approximately 1.8 million years ago. Gazelles are known as fast-running animals. Some can run at

speeds of 100 km/h (60 mph) or at a sustained speed of 50 km/h (Pas 2014). Gazelles are primarily found in the deserts, grasslands, and savannas of Africa, but they also occur in Southwest and Central Asia and on the Indian subcontinent. They tend to live in herds and feed on tender, easily digestible plants and leaves.

Gazelle Species

1) *Gazella dorcas* L.

Dorcas gazelle (*G. dorcas*), also known as the Ariel gazelle, is a small-sized gazelle species (Figure 1). Both males and females have horns, but the horns of the females are thinner, lighter, and less curved. Its color varies depending on the habitat; the white underside is bordered by a brown stripe, while the upper part is predominantly sand-colored. Its body length is 90–110 cm, and its weight is 15–20 kg. The species is distributed across the grasslands, deserts, valleys, mountain deserts, and semi-desert areas of Africa and Arabia. It is estimated that there are approximately 35,000–40,000 individuals in the wild (Grubb 2005).



Figure 1. Dorcas gazelle (*Gazella dorcas*) and its distribution.

Lifestyle and population: In unfavorable conditions, they live in pairs, whereas in more favorable environments, they live in groups consisting of one male, several females, and their offspring. It is well adapted to desert conditions and is

primarily active during the evening and night hours (Lafontaine et al. 2006).

The main threats to the species are overhunting, habitat destruction, agricultural expansion, and competition with domestic animals (Bergin & Nijman 2014; 2015).



Population figures for individual countries are reported as follows: 800–2,000 in Morocco, fewer than 2,000 in Israel, 1,000–2,000 in Egypt, and approximately 3,000 individuals in Niger. The Dorcas gazelle is classified as "Vulnerable" (VU) by the IUCN.

2) *Gazella leptoceros* F. Cuvier

The slender-horned gazelle (*G. leptoceros*), also known as the Rhim gazelle, is found in the sandy and rocky deserts of Algeria, Egypt, Sudan, and Libya (**Figure 2**). It has long legs and a slender build; its fur is light brown, while its underparts are white. Its long, slightly curved horns, large ears, and keen hearing and eyesight are adapted for life in the desert. The head and body length of adult individuals ranges from 76 to 165 cm, and the tail length is up to 31 cm. Males are larger than females. Well-adapted to dunes, this species rarely needs water, obtaining the necessary moisture primarily from the plants it feeds on. Its diet includes grass, succulents, and shrubs'

leaves; it feeds primarily at night and during the early morning hours ([Huffman & Leslie Jr 2023](#)).

Lifestyle and population: Goitered gazelles are active during the cooler parts of the day, while during the hottest hours they rest in shaded, low-lying areas. They live in small family groups, while males are encountered singly or in pairs. It has adapted to the high temperatures of the desert through a mechanism of heterothermy: it reduces water loss by raising its body temperature during the day and normalizes its temperature by dissipating heat at night ([Babor et al. 2014](#); [Dittmann et al. 2015](#)).

The species' population has declined sharply since the 1970s. While hunting for meat, horns, and decorative purposes was previously the primary threat, poaching, human activity, and habitat loss are currently the main risks. According to IUCN data, approximately 300–600 mature individuals remain worldwide. The species falls into the "Endangered" (EN) category, and its population is declining.



Figure 2. *Gazella leptoceros* and its distribution.

3) *Gazella gazella* Pallas

The mountain gazelle (*G. gazella*), or Palestinian mountain gazelle, is a widely distributed gazelle species (**Figure 3**). Both

sexes have horns, but the males' horns are larger and ringed, while the females' are shorter and thinner. The weight of males

ranges from 17 to 29.5 kg, while that of females ranges from 16 to 25 kg. This species can reach speeds of 80 km/h (Castelló 2016; Quliyev 2008).

Lifestyle and population: Mountain gazelles are diurnal and typically live in herds of 3 to 8 individuals. These herds consist of maternal groups, male groups, or solitary territorial males. During the hottest hours of the day, they rest on hill and

mountain slopes and forage at dawn and dusk.

The main threats are poaching, habitat loss and fragmentation, road accidents, as well as predation by feral dogs and jackals in certain areas. According to the IUCN Red List, the population consists of fewer than 3,000 individuals, and the species is classified as Endangered (EN).



Figure 3. *Gazella gazella* and its distribution.

4) *Gazella arabica* Lichtenstein

The Arabian Gazelle (*G. arabica*) is distributed across the Middle East, particularly in the Arabian Peninsula, Palestine, and Sinai (Figure 4). It has a slender build, a long neck and hind limbs, dark brown fur, a white belly, and a short black tail. Both sexes have horns and can run at a speed of 80 km/h. A keen sense of sight, hearing, and smell is crucial for their survival (Al Hikmani et al. 2015).

Lifestyle and population: This

species inhabits mountainous, hilly, and desert plateaus; it moves in groups, rests on hills during the day, and feeds in the morning and at night (Al Hikmani et al. 2015).

The main threats to the Arabian gazelle are illegal hunting, habitat destruction, predation, competition, and climate change. According to the IUCN Red List, the population consists of fewer than 10,000 mature individuals, and the species is classified as Vulnerable (VU).

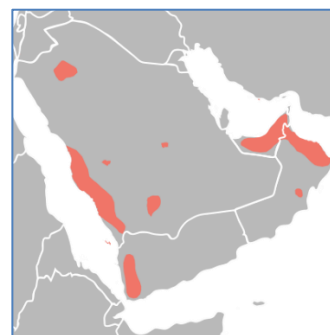


Figure 4. *Gazella arabica* and its distribution.



5) *Gazella cuvieri* Ogilby

The Cuvier's gazelle is a medium-sized antelope species distributed across North Africa, primarily in Morocco, Algeria, and Tunisia, and shares the same habitat as the dorcas and slender-horned gazelles (**Figure 5**). The shoulder height is approximately 68 cm, and the weight reaches 25 kg for females and 35 kg for males. It is characterized by a dark, long, and coarse coat, and dark-brown side stripes that contrast with the white belly and back area. Both males and females possess horns 25–37 cm in length, featuring thick rings and tips that curve forward ([Bounaceur et al. 2016](#); [Lee 2003](#)).

Lifestyle and population: Cuvier's

gazelles spend the greater part of the day feeding. Depending on the season, they feed on grasses and shrubs. Dew and bodies of water are the primary sources of water. Under high-temperature conditions, they are active primarily during the night and morning hours ([Bounaceur et al. 2016](#)).

Since the early 20th century, the population has undergone a significant decline due to overhunting, and habitat loss resulting from agriculture and livestock farming remains one of the primary threats. According to IUCN data, the species' total population is approximately 1,750–2,950 individuals, and it is classified as "Endangered" (EN).



Figure 5. *Gazella cuvieri* and its distribution.

6) *Gazella saudiya* Carruthers & Schwarz

The Saudi gazelle is an extinct species of gazelle that once ranged across the northern and western parts of the Arabian Peninsula, in areas extending from Kuwait to Yemen (**Figure 6**). It lived primarily on gravelly and sandy plains where acacias are distributed, either singly or in groups of up to 20 individuals. It was last observed in the wild in 1970, declared extinct in the wild in 1996, and officially assessed as "Extinct" (EX) on the IUCN Red List in 2008 ([Carruthers & Schwarz 1935](#)).

7) *Gazella bilkis* Groves & Lay

The Queen of Sheba's gazelle, or the Yemen gazelle, is a species considered endemic to the Taiz region of Yemen and currently regarded as extinct (**Figure 7**). The last confirmed sightings were recorded near Taizz in 1951, while surveys conducted in 1992 revealed no trace of the species. Urbanization and the loss of habitat, overhunting, and the lack of effective conservation measures are considered the primary reasons for the species' extinction. There is currently no protected area for the species, and no confirmed observations have been recorded in recent years ([Mallon & Kingswood 2001](#)).



Figure 6. *Gazella saudiya* and its distribution.

G. bilkis was distinguished by its dark-brown fur, white belly, and characteristic blackish-reddish stripes. The straight horns of the males, featuring 12–15 rings, reached a length of up to 229 mm. The species inhabited hills covered primarily with Euphorbia plants, at elevations of 1,230–

2,150 meters above sea level. Its ecological requirements were similar to those of *G. saudiya* and *G. arabica*, and the Arabian leopard and Arabian wolf were considered its primary predators (Mallon & Kingswood 2001).

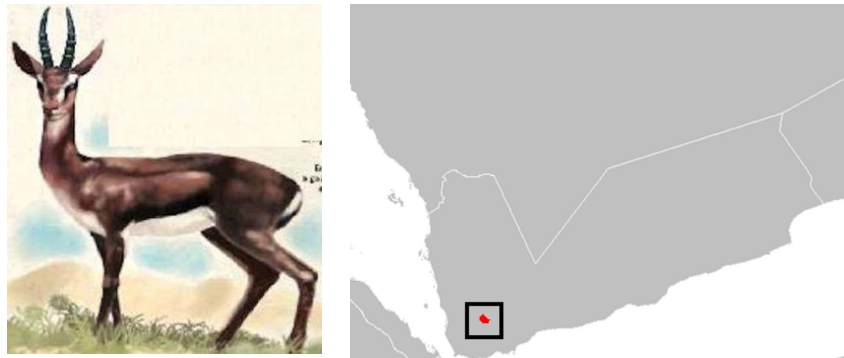


Figure 7. *Gazella bilkis* and its distribution.

8) *Gazella bennettii* Sykes

The chinkara (*Gazella bennettii*) is also known as the Indian gazelle (**Figure 8**). The species is distributed primarily in India, Iran, Pakistan, and Afghanistan (Dookia et al. 2009). Currently, the following 6 subspecies are considered valid: *G. bennettii* subsp. *bennettii* (Southern and Central India); *G. bennettii* subsp. *christii* (Pakistan and West India, Gujarat); *G. bennettii* subsp. *fuscifrons* (Eastern Iran, southern Afghanistan, Pakistan, and northwestern India; it is the darkest-colored subspecies); *G. bennettii* subsp. *karamii* (southwestern Iran, near Bushehr; it is the smallest subspecies); *G. bennettii* subsp. *shikarii*

(Northern and central parts of Iran; it is the lightest-colored subspecies); *G. bennettii* subsp. *salinarum* (Pakistan's Punjab region and the northwestern part of India) (Mallon & Kingswood 2001).

The chinkara has a body height of approximately 65 cm and weighs 23 kg. In summer, the coat is reddish-brown, whereas in winter, the belly and throat areas are whiter. Dark stripes extending from the eyes to the mouth, bordered by white lines, are observed on its face. Both males and females have horns, but the females' horns are shorter (Mallon & Kingswood 2001).

Lifestyle and habitat: The chinkara is primarily active in the evening and at night.



It feeds on leaves, grass, and other plants. It usually lives alone, in pairs, or in small groups. Males defend territory, and the species is polygynous. There are two breeding seasons per year, and the gestation period lasts 5–5.5 months. Usually one offspring is born, though sometimes two. The young stay with their mother for about a year. The chinkara primarily inhabits deserts, arid plains, scrublands, and sparse forests. It is distributed across more than 80 protected areas in India, with the densest populations located in the states of Gujarat, Rajasthan, Madhya Pradesh, and Maharashtra (Castelló 2016). In Pakistan, it is found at elevations of up to 1,500 meters,

while in Iran, the largest populations have been recorded in Kavir National Park and other protected areas.

Its main natural enemies are the Indian leopard, Bengal tiger, Asiatic lion, Indian wolf, and golden jackal, as well as, in some cases, the Indian python and the mugger crocodile. Wild dogs also pose a threat to them outside protected areas. In 2001, the population of the species in India was estimated at approximately 100,000 individuals. Populations in Pakistan and Iran have declined due to hunting, while the species has become extremely rare in Afghanistan (Solari & Baker 2007).

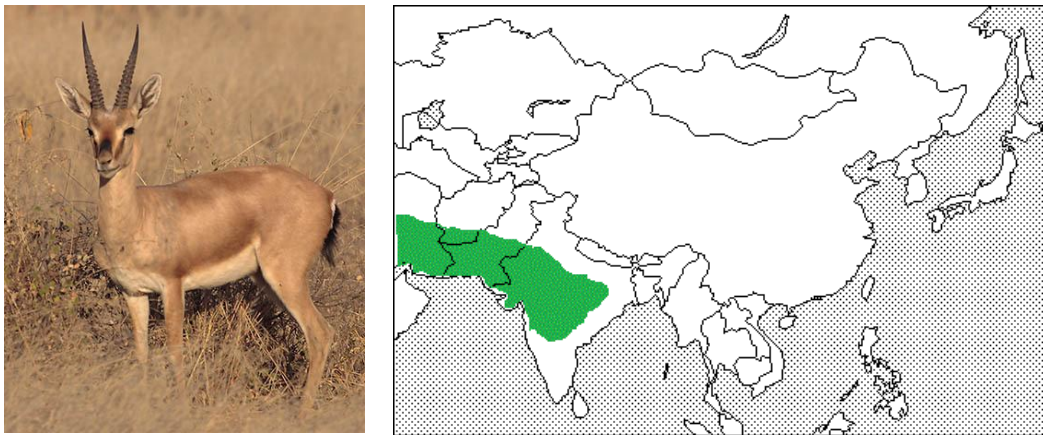


Figure 8. *Gazella bennettii* and its distribution.

9) *Gazella spekei* Blyth

Speke's gazelle (*Gazella spekei*) is the smallest species of gazelle. (Figure 9). This species is sometimes considered a subspecies of the Dorcas gazelle, although this view is no longer widely held. Severe habitat fragmentation indicates that it is no longer possible to assess the natural migration or nomadic patterns of *G. spekei*. Its numbers are at risk, and despite a population increase, the IUCN announced in 2007 that its status had changed from vulnerable to endangered. As of 2008, this gazelle is classified as endangered on the IUCN Red List. Speke's gazelle is named after the British explorer of Central Africa,

John Hanning Speke.

Body length 105 cm, shoulder height 60 cm, weight 25 kg. Slender, vertically oriented, ridged horns. Its color is pale brownish-beige, with dark brown stripes along the sides. It has a white belly and a swollen sac on its snout; it is used during encounters. It is particularly notable for its narrow, pointed face, as well as its large, exaggerated nasal passages (Hsu & Benirschke 1974).

Lifestyle and habitat: It is restricted to the Horn of Africa, where it inhabits rocky scrublands, grassy plains, and semi-deserts. The species ranges across East Africa, primarily in the eastern parts of

Somalia, extending as far as eastern Ethiopia. It inhabits semi-deserts and dry

shrublands featuring acacia trees and small shrubs (Hsu & Benirschke 1974).



Figure 9. *Gazella spekei* and its distribution.

10) *Gazella subgutturosa* Güldenstaedt

Gazella subgutturosa is the only representative of the subfamily Antilopinae in the Caucasus. On a global scale, the species is distributed from the Caucasus to Iran and eastward to Pakistan, and across Central Asia (spanning Turkmenistan, Turkey, Georgia, Azerbaijan, Iran, Iraq, Pakistan, Afghanistan, Tajikistan, Kyrgyzstan, Uzbekistan, and Kazakhstan) as far as China and Mongolia. In the Caucasus, this species is widely distributed across the semi-deserts, arid plains, and foothills of Azerbaijan and southeastern Georgia (Figure 10). Herds of goitered gazelles (*G. subgutturosa*) migrated to the Caucasus

from the Iranian-Afghan plateau following the last glacial period, displacing the saiga (*Saiga tatarica*) that had previously inhabited the region. Gazelles inhabited the primarily flat and foothill regions of the Caucasus and were a numerous species (Askerov et al. 2021; Reshag et al. 2021).

Among the animal bones discovered during excavations at the Stone Age human settlement in Gobustan, gazelle remains hold a special place. There is no shortage of petroglyphs belonging to this type among the rock art found here. Stone Age humans carved gazelles onto rocks and performed various rituals around these images before setting out to hunt.



Figure 10. *Gazella subgutturosa* and its distribution.



General Characteristics

Gazelles have a graceful and slender build. The horns are lyre-shaped, curve inwards towards the tips, and are ringed. Horns develop primarily in males. Horn length is 25–43 cm in males and up to 5 cm in females. Their color ranges from sandy to brown, with the belly and the inner parts of the legs being light-colored. Their tails are 15–20 cm long and make the white "mirror" area conspicuous when they move. Their body length is 90–115 cm, shoulder height is 60–80 cm, and weight is 18–33 kg (Castelló 2016). Females reach sexual maturity at 9 months of age, and males at 18 months. Gestation lasts 5–6 months, and usually 1–2 offspring are born. The average lifespan is 10–12 years. The time of birth varies between March and June, depending on climate and weather conditions (Quliyev 2008).

The gazelle's skeleton is strong and well-developed. In males, the skeleton is heavier than in females due to the horns. The strong development of the hind limbs is associated with its long-legged build and ability to run fast. The skull is relatively short, the neck is long, and the thoracic and lumbar regions are short. The vertebral column consists of 7 cervical, 13 thoracic, 6 lumbar, and 4 sacral vertebrae. Sexual dimorphism is observed in the structure of the pelvis. The muscle mass of the hind limbs is approximately 1.5 times greater than that of the forelimbs. The muscle mass of the hind limbs is approximately 1.5 times greater than that of the forelimbs. The primary ossification of the skeleton is completed by approximately age 2 (Blank 2025).

The skull of the goitered gazelle is characterized by well-developed lacrimal fossae, large tympanic bullae, and large horn cores in males. A broad palate and orbital region distinguish it from other gazelle species. The teeth are high-crowned

(hypsodont) and of the selenodont type, and adult individuals have 32 teeth. The young are born with milk teeth; permanent molars develop during the first year, and the replacement of teeth proceeds at approximately 14 months of age (Blank 2025).

Distribution Range and Habitat

Gazelles primarily inhabit semi-desert plains characterized by wormwood and saltwort, as well as rolling steppe areas. For this species, which is well-adapted to arid, clayey, and gravelly soils, landscapes with semi-desert vegetation constitute the primary natural habitat. In addition, gazelles can also be found in foothills and low-mountain areas. During periods of drought, they can travel several kilometers to water bodies and canals to meet their water needs. It is also observed that they move to biotopes with more favorable food and water resources, depending on seasonal conditions.

Gazelles are distributed across Iran, the South Caucasus, Asia Minor, Central Asia, Afghanistan, Pakistan, Mongolia, China, and Azerbaijan. Population numbers have declined in many areas due to the influence of historical-political and anthropogenic factors (Hoath 2009).

In Azerbaijan, gazelles primarily inhabit semi-deserts and plains. Archaeological and paleozoological findings indicate that this species has existed within the country since ancient times and lived here approximately 2 million years ago. Although they were distributed across vast areas in the mid-20th century, their numbers have declined sharply since the 1950s due to illegal hunting and habitat degradation. A total of 131 individuals were recorded in 1960–1961. Currently, the main areas of distribution are Shirvan National Park and the areas surrounding the Koroghlu River (Quliyev 2008).

In the 20th century—particularly after

the 1930s—its numbers declined rapidly due to overhunting and the loss of habitat caused by the expansion of agriculture and livestock grazing. Studies conducted in the late 1950s determined that there were fewer than 200 gazelles in Azerbaijan, with 77 of them found in the Shirvan Plain. By that time, goitered gazelles had become extinct in Georgia. The measures implemented by the Azerbaijani government in response to this—particularly the establishment of the Shirvan protected area (currently 640 km²), saved this gazelle from extinction in the Caucasus. According to recent surveys, the number in Shirvan has risen to 7,000. This figure accounts for more than 10% of the global gazelle population. Between 500 and 600 gazelles inhabit the low Bozdag Mountains in northwestern Azerbaijan—specifically in the Korchay Protected Areas, south of the Mingachevir Reservoir (Askerov et al. 2021).

The diet of gazelles consists mainly of semi-desert and desert plants. In Shirvan National Park, the primary food plants include *Nitraria* (black boxthorn), *Halostachys*, *Salicornia* (glasswort), *Artemisia* (wormwood), *Salsola*, and various meadow-marsh plants Tamarisk and Shahsevdi are particularly widespread in the area. During the winter months, ephemeral plants and low-growing shrubs are the primary sources of food. 75-80% of the vegetation in residential areas is made up of semi-desert plants. In spring, ephemeral plants develop rapidly, and at the end of summer, they form seeds and dry. From late spring onwards, the importance of bulbous plants in nutrition increases. The drying up of ephemeral plants in summer reduces the forage base. Although Lake Cala and the Shirvan collectors in Shirvan National Park play a significant role in meeting the water needs of gazelles, they do not fully satisfy their water requirements. Therefore, seasonal fluctuations in food and water

resources influence the feeding and movement of gazelles (Dittmann et al. 2015).

Population structure, seasonal adaptation and Migration

The ratio of females to males in gazelle populations varies by area. In the Korchay State Nature Sanctuary, females account for 49.2% and males for 50.8%, whereas males predominate in Shirvan National Park. Differences in age composition are also observed: in Shirvan, adult individuals account for 72%, 1–2-year-olds for 9.6%, and juveniles for 18.4%, whereas in Korchay, the corresponding figures are 63.4%, 12.6%, and 24%.

Seasonal adaptation manifests itself in the choice of habitat and in group behavior. They prefer areas with soft soil in the summer and hard soil in the winter. Although they do not undertake long-distance migrations, seasonal movements do occur. During the autumn and winter months, herds merge to form large groups, whereas in late spring, they split into smaller groups.

Its coat also changes according to the season: sparse and brown in summer, but dense, long, and pale yellowish in winter. Molting occurs twice a year—in spring and autumn—and helps regulate temperature. Gazelles mark their territories by scraping the ground and leaving scent marks.

Gazelles are one of the actively migrating species of even-toed ungulates (Artiodactyla). During the spring and summer months, their activity increases depending on food and water supplies, while they rest in cool, shaded areas during the hottest hours. In winter, cold weather and food shortages compel them to migrate to more favorable areas. They show a preference for areas where water and food resources are more accessible, particularly during the months of March to May.



Keen eyesight, hearing, and sense of smell help gazelles protect themselves from predators. In Azerbaijan, Shirvan National Park and the areas surrounding Kangarli and Korchay are important habitats for gazelles. Food and water shortages and high temperatures affect their movement. The use of feed blocks for supplementary feeding in Shirvan National Park causes gazelles to congregate in specific areas.

Natural Enemies, Diseases, and Parasites

The main natural enemy of gazelles is the wolf. Newborns and cubs aged 15–20 days, however, are easy prey for wolves, foxes, jackals, steppe and jungle cats, stray dogs, and birds of prey. Living in open areas enables gazelles to detect danger in time and flee.

Gazelles are affected by external parasites, such as ticks, botflies, lice, and chewing lice, as well as internal parasites, primarily gastrointestinal helminths. Around 20 species of helminths have been recorded in Azerbaijan, and diseases such as tularemia, foot-and-mouth disease, fascioliasis, avitellinosis, and haemonchosis have been observed. Sharing pastures and water sources with livestock increases the risk of disease transmission.

Competition for food is also one of the factors affecting the population. Livestock and rodents can limit the gazelles' food supplies. Therefore, the protection of the habitat, the prevention of illegal hunting, the proper management of water and pasture resources, and the monitoring of diseases are essential.

The Economic and Cultural Significance of Gazelles

As an important part of Azerbaijan's biodiversity, gazelles play a role in maintaining the natural balance of ecosystems. Their elegant appearance and

distinctive behaviors have made them objects of human attention and interest for many centuries.

Gazelles are widely reflected in Azerbaijani poetry, art, and cultural heritage as symbols of natural beauty. Their economic, as well as potential biotechnological and breeding, significance is also noted. Historically, the gazelle has been considered a sacred and inviolable animal, and hunting it has been regarded as a sin. For this reason, the gazelle has been regarded as a symbol of kindness, peace, and reconciliation.

Conservation measures have been implemented worldwide. Gazelles are herbivorous mammals distributed primarily across Africa, Asia, and the Middle East, inhabiting arid and semi-desert environments. In recent decades, their natural population has declined sharply. Key factors contributing to this decline include habitat loss, illegal hunting, the expansion of agricultural areas, climate change, and natural barriers created by infrastructure (roads, fences, etc.). For example, the dama gazelle (*Nanger dama*) was formerly widespread across the Sahel zone. Currently, however, with fewer than 100 individuals remaining in the wild, it has been classified as "Critically Endangered" by the IUCN.

Restoration of goitered gazelles in Azerbaijan and Georgia

In the early 20th century, approximately 60,000 goitered gazelles (*Gazella subgutturosa*) lived in Azerbaijan. However, by the 1960s, this number had dropped below 200. Currently, as a result of reintroduction programs implemented through the joint initiative of WWF and IDEA, the number of gazelles exceeds 6,000 ([Askerov et al. 2021](#)).

Since 2013, under this program, more than 80 individuals have been translocated from Shirvan National Park to Georgia (the

Samukh Plain and the vicinity of Vashlovani Reserve), and nine generations of newborn gazelles have already been produced.

The goitered gazelle (*Gazella subgutturosa*) experienced a sharp decline in Azerbaijan during the 20th century as a result of agricultural expansion and intensive hunting. The species is classified as Vulnerable (VU) on the IUCN Red List and is included among the species requiring special protection in the Red Book of Azerbaijan (Askerov et al. 2021).

Approximately 160 gazelles have been relocated from Shirvan National Park to their historical habitats within the framework of a reintroduction program involving the Heydar Aliyev Foundation, the Ministry of Ecology and Natural Resources, IDEA, and the WWF. Approximately 160 gazelles have been relocated from Shirvan National Park to their historical habitats within the framework of a reintroduction program involving the Heydar Aliyev Foundation, the Ministry of Ecology and Natural Resources, IDEA, and the WWF. Conservation measures include population monitoring, ranger training, the use of modern surveillance equipment, and awareness-raising activities (Groves & Grubb 2011).

Conclusion

The genus *Gazella* consists of species with diverse morphological, ecological, and geographical characteristics, most of which are adapted to arid and semi-arid environments. However, habitat loss, illegal hunting, agricultural expansion, livestock grazing, competition for resources, and climate change have caused a significant decline in the population and, in some cases, its extinction.

Effective protection requires the conservation and restoration of the habitat, the prevention of illegal hunting, the monitoring of populations and diseases, the

sustainable management of food and water resources, and the maintenance of ecological corridors. Reintroduction and translocation programs can also contribute to the restoration of populations within their historical ranges. The recovery of the goitered gazelle (*Gazella subgutturosa*) in Azerbaijan demonstrates the effectiveness of coordinated conservation efforts. The protection of Shirvan National Park, population monitoring, anti-poaching measures, and reintroduction programs have contributed to the recovery of this species. Ongoing scientific research, public awareness, and national and international cooperation are essential to ensure the long-term survival of gazelles and to preserve their ecological and cultural significance.

Conflict of Interest

The authors declare that there is no conflict of interest.

References

- Al Hikmani H., Zabanoot S., Al Shahari T., Zabanoot N., Al Hikmani K., Spalton A. (2015) Status of the Arabian Gazelle, *Gazella arabica* (Mammalia: Bovidae), in Dhofar, Oman. *Zoology in the Middle East*, 61(4), 295–299. Doi: [10.1080/09397140.2015.1101905](https://doi.org/10.1080/09397140.2015.1101905)
- Askerov E., Mallon D.P., Zazanashvili N., Kochiashvili V., Sarukhanova S., Muradov A. (2021) An attempt to restore the population of the Goitered Gazelle (*Gazella subgutturosa*) in its indigenous range in the Caucasus (Mammalia: Bovidae). *Zoology in the Middle East*, 67(3), 189–197.
- Babor H., Okab A.B., Samara E.M., Abdoun K.A., Omar Al-Tayib O.A.T., Al-Haidary A.A. (2014) Adaptive thermophysiological adjustments of gazelles to survive hot summer conditions. *Pakistan J. Zool.*, 46(1), 245–252.



- Bergin D., & Nijman V. (2014) Open, unregulated trade in wildlife in Morocco's markets. *Traffic Bull*, 26(2), 65–70.
- Bergin D., & Nijman V. (2015) Trade of ungulates in Moroccan markets for decoration and medicinal use. GNUSLETTER.
- Blank D. (2025) The behavioral biology and conservation of goitered gazelles (*Gazella subgutturosa*). Springer Nature.
- Bounaceur F., Boualem A., Benamor N., Fellous A., Benkheira A., Bissaad F.Z., Aulagnier S. (2016) Updated distribution and local abundance of the endangered Cuvier's gazelle (Mammalia, Bovidae) in Algeria. *Folia Zoologica*, 65(3), 233–238.
- Carruthers D., & Schwarz E. (1935). On a new *Gazelle* from Central Arabia. In *Proceedings of the Zoological Society of London* (Vol. 105, No. 1, pp. 155–156). Oxford, UK: Blackwell Publishing Ltd.
- Castelló J.R. (2016) Bovids of the world: antelopes, gazelles, cattle, goats, sheep, and relatives (Vol. 104). Princeton University Press.
- Dittmann M.T., Hebel C., Arif A., Kreuzer M., Clauss M. (2015) Metabolic rates of three gazelle species (*Nanger soemmerringii*, *Gazella gazella*, *Gazella spekei*) adapted to arid habitats. *Mammalian Biology*, 80(5), 390–394.
- Dookia S., Rawat M., Jakher G.R., Dookia B.R. (2009) Status of the Indian Gazelle (*Gazella bennettii* Sykes, 1831) in the Thar Desert of Rajasthan, India. In *Faunal ecology and conservation of the Great Indian Desert* (pp. 193–207). Berlin, Heidelberg: Springer Berlin Heidelberg.
- Groves C., & Grubb P. (2011) Ungulate taxonomy. Johns Hopkins University Press, Baltimore, Maryland, 317 p.
- Grubb P. (2005) Order Artiodactyla. *Mammal Species of the World. A Taxonomic and Geographic Reference 3rd edition*, 1, 637–722.
- Hoath R. (2009). A field guide to the mammals of Egypt. American Univ in Cairo Press.
- Hsu T.C., & Benirschke K. (1974) *Gazella spekei* (Speke's gazelle). In: An Atlas of Mammalian Chromosomes. Springer, New York, NY. Doi: [10.1007/978-1-4615-6432-4_45](https://doi.org/10.1007/978-1-4615-6432-4_45)
- Huffman B.A., & Leslie Jr D.M. (2023) *Gazella leptoceros* (Artiodactyla: Bovidae). *Mammalian Species*, 55(1032), sead007.
- Khaleel I., & Salih A. (2017) Comparative anatomical study of thyroid gland in adult indigenous gazelle (*Gazella subgutturosa*) and sheep. *Kufa Journal for Veterinary Medical Sciences*, 8(2), 245–252.
- Lafontaine R.M., Beudels-Jamar R.C., Devillers P., Wachter T. (2006) *Gazella dorcas*. Sahelo-Saharan Antelopes: Status and Perspectives. Report on the Conservation Status of the Six Sahelo-Saharan Antelopes. UNEP/CMS Secretariat, Bonn, Germany.
- Lee K. (2003) *Gazella gazella*. Animal Diversity Web [Internet].
- Mallon D.P., & Kingswood S.C. (2001) Antelopes. Part 4: North Africa, the Middle East, and Asia. Global Survey and Regional Action Plans. SSC Antelope Specialist Group, IUCN, Gland, Switzerland and Cambridge, England.
- Pas A. (2014) Gazelle and small antelope. *Zoo animal and wildlife immobilization and anesthesia*, 843–856.
- Quliyev S.M. (2008) Bioloji müxtəliflik: Azərbaycanın cüdnəqlilər faunası.



- Şərqi Qafqaz turu və Qafqaz köpgəri.
Bakı.
Reshag A.F., Hussein A.A., Kadhim M.S.
(2021) Histological study of ureter and
urinary bladder of the adult black-
tailed gazelle (*Gazella subgutturosa*).
Solari S., & Baker R.J. (2007) Mammal
species of the world: a taxonomic and
geographic reference by DE Wilson;
DM Reeder.



MICROBIOLOGICAL FEATURES AND MECHANISMS OF ANTIBIOTIC RESISTANCE OF BIOFILM FORMATION IN BACTERIA OF CLINICAL ORIGIN

Lamiya Jeyhun Khalilzada¹, Aygun Samad Suleymanova^{1*}  

Western Caspian University, Department of Natural Sciences, Baku, AZ1072, Azerbaijan

Abstract: The existence of bacteria within biofilms provides high resistance against environmental stress, host immune responses, and antimicrobial agents. In this study, the biofilm formation capacity, architectural organization, and resistance mechanisms of six major clinical pathogens (*Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Escherichia coli*, *Klebsiella pneumoniae*, *Acinetobacter baumannii*) were evaluated through comparative and systematic microbiological analyses. The findings indicate that 66.7% of the analyzed isolates are Gram-negative and 66.7% are facultative anaerobes, with 100% displaying colonization capabilities on medical device surfaces. Extracellular polymeric substances (EPS), extracellular DNA (eDNA), outer membrane vesicles (OMVs), and quorum sensing systems play critical roles in recalcitrance and survival.

Keywords: biofilm, clinical pathogens, extracellular matrix, antibiotic resistance, quorum sensing, nosocomial infections.

*Corresponding author: aygun.suleymanova@wcu.edu.az

Received: 17 August 2026 Accepted: 31 August 2026 Published: 18 September 2026

DOI: 10.54414/MZOG7193

Introduction

One of the most pressing challenges facing microbiology and clinical medicine in the modern era is the resistance mechanisms developed by microorganisms to antibiotics. According to the World Health Organization (WHO), effective treatment of infectious diseases is becoming increasingly complex and poses global epidemiological risks as a result of the spread of antibiotic-resistant bacteria (Percival et al. 2015). Studies show that in natural and hospital environments, microorganisms exist in the form of biofilms — cell communities that live within the polymer matrix secreted by themselves, adhering to surfaces rather than in the free

planktonic form (Donlan & Costerton 2002; Zhang et al. 2024).

The widespread use of catheters, artificial heart valves, orthopedic prostheses, endotracheal tubes, and other invasive devices in medical practice create favorable conditions for the formation of biofilms (Hall-Stoodley et al. 2004; Flemming et al. 2016; Percival et al. 2015). Bacteria located within the biofilm are protected against both immune reactions of the body (phagocytosis, antibodies) and traditional antibiotic therapy, causing recurrent and chronic nosocomial infections (Ciofu & Tolker-Nielsen 2019; Sharma et al. 2019). From this point of



view, the comparative study of the stages of biofilm formation, the biochemical composition of the matrix, and the mechanisms of resistance to antibiotics in bacteria of clinical origin are of theoretical and practical importance (Høiby et al. 2010; Liu et al. 2024).

Materials And Methods

In this research, six main pathogens, which are widespread in clinical practice and can form biofilms, were selected for analysis: *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Escherichia coli*, *Klebsiella*

pneumoniae, and *Acinetobacter baumannii*.

The research methodology is based on the methods of systematization of scientific literature data, comparative microbiological analysis, tabulation, and descriptive-statistical generalization. The Gram affiliation, oxygen requirement, primary adhesion structures (whip, pili, fimbriae, adhesins), extracellular matrix components (alginate, PIA, extracellular DNA, capsule), Quorum Sensing systems, and clinical colonization foci of each selected pathogen species were compared, as shown in **Table 1**.

Table 1. Comparison of biofilm-forming characteristics of major pathogens of clinical origin.

Bacteria Type	Gram Type	The Relationship Between Oxygen and Oxygen	Main Adhesion and Matrix Factors	Clinical Source/Significance
<i>Pseudomonas aeruginosa</i>	Gram-negative	Aerobe	Whip, Battery, Alquin Matrix, Quorum Sensing	Lung (cystic fibrosis), burn wounds, respiratory tubes
<i>Staphylococcus aureus</i>	Gram-positive	Facultative anaerobic	Adhesins, amyloid fibers, protein-polysaccharide matrix	Chronic wounds, skin infections, catheters, prostheses
<i>Staphylococcus epidermidis</i>	Gram-positive	Facultative anaerobic	Polysaccharide intercellular adhesin (PIA), surface proteins	Catheters, Artificial Heart Caps, Orthopedic Implants
<i>Escherichia coli</i>	Gram-negative	Facultative anaerobic	Fimbriae, battery, eDNA, amyloid fibers (Curli)	Urinary catheters, recurrent urinary tract infections
<i>Klebsiella pneumoniae</i>	Gram-negative	Facultative anaerobic	Thick capsule polysaccharides, fimbrial adhesion	Respiratory tract, artificial ventilation devices, urinary tract
<i>Acinetobacter baumannii</i>	Gram-negative	Aerobe	Outer membrane proteins, OMV secretion, dry surface tolerance	Resuscitation equipment, wound infections, devices

Results and Discussion

Stages of Biofilm Formation and Matrix Architecture

The process of biofilm formation of clinical bacteria takes place in four main phases: primary (reversible) adhesion, fixation (irreversible binding), maturation,

and dispersion, which is characterized by the formation of microcolonies. In the initial phase, weak electrostatic and hydrophobic interactions with the abiotic surface are established by means of pili and batteries. In the irreversible phase, surface adhesions are activated, and the synthesis of extracellular



polymeric substances (EPS) is activated. In the adult biofilm phase, a complex system of 3D water channels is formed, which ensures the transport of food and oxygen to the inner layers, as well as the excretion of metabolites. During the dispersion phase, some bacteria leave the matrix and return to the planktonic form, colonizing new tissue or implant surfaces.

Up to 90% of the biofilm mass is made up of water, and 50–90% of the dry mass is made up of polysaccharides. Structural

proteins, lipids, extracellular DNA (eDNA), and bivalent cations such as Ca^{2+} and Mg^{2+} within the matrix form ion bridges, ensuring the structure's rheological elasticity and mechanical stability.

Statistical Generalization of Microbiological Indicators

The total percentage distribution of microbiological parameters for clinical pathogens included in the analysis is presented in **Table 2**.

Table 2. Distribution of biofilm pathogens by basic microbiological properties

And then there's the parameter that comes with it	Number of species	Interest Share (%)	Microbiological Significance
Gram-negative pathogens	4 / 6	66.7%	Strong aggregation by outer membrane, capsule, battery, and OMV secretion
Gram-positive pathogens	2 / 6	33.3%	Mechanism of Adhesion Proteins and Polysaccharide Intercellular Adhesion (PIA)
Facultative anaerobic types	4 / 6	66.7%	Metabolic plasticity and survival in deep anoxic layers
Absolute Aerobic Species	2 / 6	33.3%	Respiratory system and intensive development on open biotic/abiotic surfaces
Colonization on the surface of a medical device	6 / 6	100.0%	Universal biofilm potential on catheter, prosthetic and implant surfaces
Polysaccharide/Capsule Matrix Species	5 / 6	83.3%	Ensuring the protective and rheological stability of the EPS matrix
Movement and fimbrial adhesion	4 / 6	66.7%	Acceleration of primary adhesion and strengthening of microcolonies

Mechanisms of Tolerance and Resistance to Antibiotics

The high resistance of bacteria to antimicrobial substances within the biofilm is determined by complex factors interacting with each other:

- Diffusion barrier and electrostatic trap: A dense EPS matrix and negatively charged extracellular DNA (eDNA) bind to positively charged antibiotics (e.g., aminoglycosides) and prevent their free diffusion into the inner

layers.

- Persistent cells and metabolic stagnation: Hypoxia and malnutrition that occur deep in the biofilm move cells into a slow or passive metabolic phase. Drugs such as β -lactames, which target multiplying cells, are unable to affect this persistent population.
- Outer Membrane Vesicles (OMVs): OMVs secreted by Gram-negative pathogens such as *P. aeruginosa* and



A. baumannii inactivate antibiotic molecules by capturing them on the surface before reaching the cell.

- Utilization of Neutrophil Extracellular Traps (NETs): DNA chains released by neutrophils at the infection site are incorporated into the EPS matrix by *S. aureus* and *K. pneumoniae* as mechanical fixtures, further strengthening the biofilm architecture.
- Efflux pumps and Horizontal Gene Transfer (HGT): Efflux pumps, activated by quorum sensing signals, remove antibiotics from the cell. At the same time, the dense location of the cells accelerates the transmission of resistance plasmids by conjugation.

Conclusions and Suggestions

Biofilm formation in bacteria of clinical origin is an important adaptation strategy that allows them to evade drugs and the body's immune control. The study shows that most biofilm-forming pathogens are Gram-negative (66.7%) and facultative anaerobic (66.7%) and have 100% colonization ability on medical implants and catheters. The biofilm matrix acts not only as a mechanical barrier but also as a biochemically active defense system. As practical suggestions, the following are offered:

- Regular microbiological monitoring should be carried out for the early detection of biofilm-forming strains in clinical facilities and intensive care units.
- The use of nanotechnological coatings with antibiofilm properties in the use of invasive medical devices (catheters, implants, prostheses) should be expanded.
- To prevent the adaptation of bacteria to sublethal doses, strict adherence to the protocols for the rational use of antibiotics should be strictly observed.

Conflict of Interest

The authors declare that there is no conflict of interest.

References

- Donlan R.M., Costerton J.W. (2002) Biofilms: survival mechanisms of clinically relevant microorganisms. *Clinical Microbiology Reviews*, 15(2): 167–193.
- Stewart P.S., Costerton J.W. (2001) Antibiotic resistance of bacteria in biofilms. *The Lancet*, 358: 135–138.
- Hall-Stoodley L., Costerton J.W., Stoodley P. (2004) Bacterial biofilms: from the natural environment to infectious diseases. *Nature Reviews Microbiology*, 2:95–108.
- Flemming H.C., Wingender J., Szewzyk U., Steinberg P., Rice S.A., Kjelleberg S. (2016) Biofilms: an emergent form of bacterial life. *Nat Rev Microbiol.*, 14(9):563–575. Doi: [10.1038/nrmicro.2016.94](https://doi.org/10.1038/nrmicro.2016.94).
- Ciofu O., Tolker-Nielsen T. (2019) Tolerance and resistance of *Pseudomonas aeruginosa* biofilms to antimicrobial agents. *Frontiers in Microbiology*, 10: 913.
- Percival S.L., Suleman L., Vuotto C., Donelli G. (2015) Healthcare-associated infections, medical devices and biofilms. *Journal of Medical Microbiology*, 64: 323–334.
- Sharma D., Misba L., Khan A.U. (2019) Antibiotics versus biofilm: an emerging battleground in microbial communities. *Antimicrobial Resistance and Infection Control*, 8: 76.
- Høiby N., Bjarnsholt T., Givskov M., Molin S., Ciofu O. (2010) Antibiotic resistance of bacterial biofilms. *Int J Antimicrob Agents*, 35(4):322–332. Doi: [10.1016/j.ijantimicag](https://doi.org/10.1016/j.ijantimicag)
- Liu H.Y., Prentice E.L., Webber M.A. (2024) Mechanisms of antimicrobial



resistance in biofilms. *Antimicrobials and Resistance*, 2(1): 27.

Zhang R., Li G., Wu Y., Wang X., Luan Q. (2024) Pathogenic mechanisms and potential applications of extracellular vesicles from periodontal pathogens in periodontitis. *Front. Immunol.* 15:1513983. Doi: [10.3389/fimmu.2024.1513983](https://doi.org/10.3389/fimmu.2024.1513983).



STABILITY OF POTASSIUM AND LDH INDICATORS IN HEMOLYTIC AND LIPEMIC BLOOD SERUM

Fidan Mubarizsoy^{1*}✉, Aygun Samad Suleymanova¹✉, Ayaz Israfilov²✉, Namiq Iskandarov²✉

¹Department of Natural Sciences, Western Caspian University, AZ1072, Baku, Azerbaijan

²Memorial Hospital, Baku, Azerbaijan

Abstract: Hemolysis and lipemia disrupt the stability of potassium (K) and lactate dehydrogenase (LDH) indicators in the preanalytical stage, causing falsely high results (pseudo-hyperkalemia). Erythrocyte breakdown (hemolysis) and optical interference from lipids lead to serious diagnostic errors in laboratory analyses. To avoid diagnostic paradoxes, the H-index and L-index should be checked automatically, and samples exceeding the critical limit should be re-analyzed. Studies conducted at the Memorial Hospital clinical laboratory have confirmed that hemolysis and lipemia are serious preanalytical interference factors, especially in the determination of lactate dehydrogenase and potassium. RBC fragmentation leads to pseudo-hyperkalemia, and lipemia reduces the accuracy of the results due to optical interference. These interferences create systematic deviations in laboratory indicators, increasing the risk of making incorrect clinical decisions. Therefore, strengthening sample quality control at the preanalytical stage plays a crucial role in the reliability of diagnostics. The study investigated the effects of hemolysis and lipemia on serum Potassium (K) and Lactate Dehydrogenase (LDH) levels and found that these interferences lead to false hyperkalemia and analytical bias. The results demonstrate the importance of H-index and L-index monitoring for critical diagnostic decisions in laboratory diagnostics. The objective of the experiment is to qualitatively evaluate analytical bias introduced by experimentally induced hemolysis and lipemia in serum K and LDH levels under controlled laboratory conditions and to assess their clinical significance and total allowable error (TAE) limits.

Keywords: preanalytical errors, hemolysis, lipemia, lactate dehydrogenase, potassium, clinical chemistry, HIL index, analytical bias.

*Corresponding author: mbarizsoy@mail.ru

Received: 7 August 2026

Accepted: 18 August 2026

Published: 18 September 2026

DOI: 10.54414/UJGY1258

Introduction

The factor that most affects the objectivity of the results in clinical laboratory diagnostics and is considered one of the most critical errors in the preanalytical stage is the breakdown of erythrocytes, that

is, hemolysis (Alkhatib 2019; Atay et al. 2014). The leakage of intracellular elements into the serum is not just a technical defect but a serious threat that can directly lead to incorrect clinical decisions (Lippi et al.

2009; 2018). Statistics show that hemolysis is the cause of more than 60% of rejected samples, and it occurs five times more often than other preanalytical defects (Lippi et al. 2018; Salvagno et al. 2019). Technical errors made during venipuncture, sharp temperature fluctuations, and vibration during transportation are proximal sources that lead to in vitro damage to the erythrocyte membrane (Atay et al. 2014; Urwin et al. 2015; Hébert et al. 2005).

When cellular integrity is compromised, the leakage of internal analytes such as potassium, lactate dehydrogenase (LDH), and aspartate transaminase (AST) into the extracellular medium creates spectrophotometric interference, causing artificial elevations in test results (Atay et al. 2014; Farhana & Lappin 2021). Since the human eye cannot objectively assess these subtle color changes visually, the integration of automated systems and serological index (SII) measurements is inevitable. Automated management eliminates subjectivity, spectrally corrects for analytical bias, and reduces the need for repeated blood transfusions for the patient (Lippi et al. 2009; 2018).

However, there is significant heterogeneity in SII results from different platforms such as Roche, Abbott, Siemens, and Beckman Coulter (Lippi et al. 2018; Nikolac 2014; Tang et al. 2024). This variability necessitates the application of uniform standards between laboratories. In this regard, the study aims to analyze the interference mechanisms of hemolysis and systematize internal quality programs so that each laboratory can individually verify the analytical principles of HIL indices, including coagulation (Atay et al. 2014).

In clinical laboratory practice, one of the most important preanalytical factors that directly affects sample quality and seriously undermines the reliability of results is

lipemia. This condition, characterized by a higher-than-normal lipid concentration in blood plasma or serum, causes samples to appear macroscopically cloudy, sometimes completely milky. Scientific sources note that this macroscopic change is often associated with a sharp increase in triglyceride levels; this condition can occur both due to physiological (postprandial) factors after food intake and due to pathological causes such as various metabolic disorders, hyperlipidemia, and diabetes mellitus. The main danger posed by lipemia is not the visual appearance of the biological material, but the optical chaos it creates in biochemical measuring instruments. Turbidity changes the physical properties of the sample, causing direct interference in spectrophotometric-based analyses and leading to incorrect calculation of results (Lippi et al. 2009; 2018). According to studies, the absorption or scattering of light by lipid particles impairs the measuring mechanism of the device, which leads to artificially increasing or decreasing analyte concentrations (Calmarza & Cordero 2011; McDonough & Youn 2017; Schlüter & Cadamuro 2023). In addition, excessively fatty samples completely block the operation of optical sensors, causing technical failures in the analyzers and complicating the internal quality control of the laboratory. In this regard, the measurement of automated HIL indices is indispensable for timely prediction of potential complications of lipemia. Although the lipemia index (L index) does not always form a complete mathematical correlation with triglyceride concentration, it allows for an objective assessment of the actual degree of turbidity in the sample and the optical obstacle that the device will encounter. This index helps to control the analytical environment more transparently by measuring the contamination caused by large lipoproteins, especially chylomicrons



or VLDL (very low-density lipoproteins), at a wavelength of 660 nm or 700 nm. The interference mechanism of lipemia is not limited to light scattering or absorption; factors such as unequal partitioning of analytes between polar and nonpolar phases, as well as a decrease in the water fraction (volume shift error), also play a role. This situation falsely lowers the electrolyte concentrations measured by indirect potentiometry (Nikolac 2014; Tang et al. 2024). Although it has been proposed to develop standardized lipemic models in laboratories to investigate this interference, models built with artificial substances such as Intralipid cannot fully reflect the lipoprotein heterogeneity in real patient blood. For this reason, the use of natural lipemic sera should be preferred in the evaluation (Berman & Hayes 2024; Nikolac 2014). To prevent misdiagnosis during laboratory tests, appropriate purification methods are needed to overcome this lipid barrier (Farhana & Lappin 2021; Zhou et al. 2022). Although ultracentrifugation, which is considered the reference method, effectively separates lipids, its high cost, non-availability in every laboratory, and prolonged analysis time (TAT) are serious disadvantages. For this reason, many clinical laboratories are turning to high-speed microcentrifugation, a more economical and rapid alternative. Studies have shown that this method demonstrates almost the same efficiency as ultracentrifugation in the determination of routine analytes such as sodium, creatinine, urea, and total protein. However, although high-speed conventional centrifugation easily precipitates the turbidity caused by chylomicrons, it cannot ensure complete separation in samples dominated by smaller VLDL particles; in this regard, ultracentrifugation still maintains its leadership. In some cases of mild lipemia, the use of a serum blank (serum correction) may eliminate the need

for physical purification. In laboratories with limited material and technical resources, chemical precipitation methods using polyethylene glycol 6000 (PEG) or various cyclodextrins (alpha, gamma) are used as an alternative to physical methods. These chemical agents aggregate and precipitate lipid particles and minimize false glucose and albumin changes in photometric analyses. PEG concentrations ranging from 4% to 8% restore the accuracy of enzymatic reactions such as AST and ALT by providing optimal purification in a triglyceride environment of 300–500 mg/dL. Of course, the risk of partial inhibition of enzyme activity by extremely high PEG concentrations such as 20% should not be forgotten, and appropriate dilution corrections should be performed (Wu et al. 2021; Zhou et al. 2022).

Materials and Methods

This controlled experimental laboratory study was conducted at the Clinical Biochemistry Laboratory of Memorial Hospital (Baku, Azerbaijan) to systematically quantify the analytical interference and bias introduced by preanalytical hemolysis and lipemia on serum potassium (K^+) concentrations and lactate dehydrogenase (LDH) activity. A total of 23 non-interfered residual venous blood specimens were prospectively selected from adult patients undergoing routine health screenings. Venipuncture was performed by certified phlebotomists adhering strictly to the Clinical and Laboratory Standards Institute (CLSI GP41-A6) guidelines. Blood was drawn into 5 mL serum separator tubes (SST) containing a clot activator and acrylic polymer gel. To eliminate iatrogenic preanalytical artifacts during collection, standardized protocols were enforced: tourniquet application was restricted to under 60 seconds, gentle tube inversion (5–8 times) was performed, and

mechanical shear stress from forceful aspiration was strictly avoided. Specimens exhibiting micro-clots, inadequate volume (<2.5 mL), or visually detectable baseline hemolysis, lipemia, or icterus were immediately excluded.

Following phlebotomy, specimens were allowed to complete clot retraction at ambient room temperature (20–22°C) for exactly 30 minutes before centrifugation. Centrifugation was executed at 3500 rpm (equivalent to 2000×g) for 15 minutes at 4°C in a temperature-controlled centrifuge. Uncontaminated baseline serum pools were

immediately decanted into secondary polypropylene tubes to prevent cellular leakage. Controlled hemolysis was simulated via Vitruvian-calibrated mechanical disruption of autologous packed red blood cells obtained from the cell pellet, yielding escalating hemoglobin concentration gradients across paired aliquots. Lipemia was experimentally induced through the standardized addition of a 20% intravenous lipid emulsion (Intralipid), creating serial turbidity profiles ranging from mild opalescence to severe milky opacity (**Figure 1**).

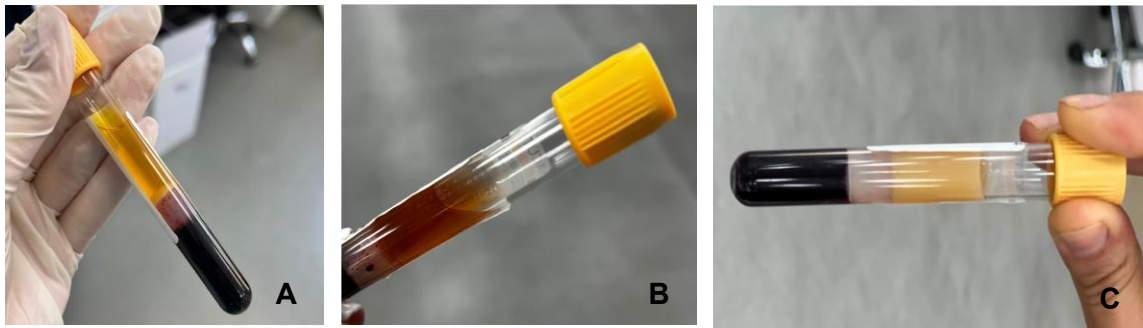


Figure 1. Examined blood samples. **A.** Blood sample after centrifugation; **B.** Hemolytic blood; **C.** Lipemic blood.

Analytical determinations were executed on automated clinical chemistry analyzer platforms under standardized ambient conditions. Serum potassium was measured utilizing an Ion-Selective Electrode (ISE) module operating via potentiometric measurement. LDH catalytic activity was quantified through an IFCC-standardized kinetic enzymatic assay at 340 nm, tracking the rate of nicotinamide adenine dinucleotide (NADH) oxidation during the reversible reduction of pyruvate to lactate. Analytical reliability was guaranteed by processing two levels (normal and pathological) of certified liquid internal quality control (IQC) materials before each run, ensuring total analytical imprecision remained well within target allowable limits. To suppress inter-assay drift and matrix alterations, all experimental aliquots were

analyzed in duplicate within a single operational batch; short-term storage, when necessary, was restricted to 2–8°C for a maximum of 4 hours, strictly avoiding freeze-thaw cycles.

Statistical processing was performed using IBM SPSS Statistics (Version 29.0; IBM Corp., Armonk, NY, USA). Continuous parametric metrics were summarized as mean $\pm$ standard deviation (SD), whereas non-parametric data were presented as median and interquartile range (IQR). The normality of data distributions was tested using the Shapiro–Wilk test alongside visual inspection of Q-Q plots. Paired-sample t-tests or repeated-measures analysis of variance (ANOVA) with Tukey's post hoc correction were utilized to evaluate parametric within-subject concentration shifts across interference tiers. Non-



parametric variables were evaluated using Wilcoxon signed rank or Friedman tests. Linear regression models and Pearson (r) or Spearman (ρ) correlation coefficients were calculated to model interference-bias response curves. Statistical significance was designated at a two-tailed $p < 0.05$. The protocol maintained complete compliance with the ethical directives of the Declaration of Helsinki, utilizing fully anonymized residual diagnostic specimens without patient contact or clinical care disruption.

Results

1. Complex pathophysiological analysis of LDH activity, potassium levels, and specific markers in different age and sex groups of hemolytic blood

To assess cellular integrity, internal homeostasis, and metabolic processes at different ages, a retrospective analysis was performed on the laboratory profiles of three patients of different age and gender groups examined at the Memorial Hospital laboratory. Within the framework of the study, lactate dehydrogenase (LDH) enzyme activity and potassium ion dynamics were examined in parallel with other specific biochemical and endocrine markers in the context of different ages.

2. Pathophysiological evaluation of LDH activity and anabolic markers in the pediatric age group

To evaluate the biochemical dynamics in the pediatric age group, the laboratory parameters of a 3.5-year-old male patient were analyzed. The patient's serum LDH level was determined to be 297 U/L and was within the upper reference limit (314 U/L) set for that age group, i.e., within the physiological normal range (Figure 2). Against the background of intensive growth and tissue development of the general organism in children, it is a normal physiological pattern that the basal level of this enzyme is higher than in adults. The concentration of somatotrophic hormone (STH), which characterizes the patient's anabolic status, was found to be 1.41 ng/mL, which is fully adequate to the reference range set for children (0.067–2.167 ng/mL). At the same time, the Vitamin B12 level was also recorded at 575.8 pg/mL, within the ideal median of the reference range (201–804 pg/mL). This indicator confirms, from a pathophysiological point of view, that there is no hidden hematological dysfunction (e.g., megaloblastic anemia and associated ineffective erythropoiesis in the bone marrow) that could lead to falsely elevated LDH levels in vitro.

Təsdiq	Açar	Xidmət Adı	Flg	Nəticə	Sənəd Status	Nəticə Qrupu	Modul	Min	Max	Qihaz Vəziyyəti	İzah
☒	☐	LDH*		204		Biokimya	U/L	135	214		
☒	☐	Ca total (qan)*		2,51		Biokimya	mmol/L	2,2	2,55		
☒	☐	Parathormon*		15,28		Hormonal müay.	pg/mL	15	65		
☒	☐	CA 15-3*		26,84		Onkomarker	U/mL	<	30		
☒	☐	CEA*		1,29		Onkomarker	U/mL	<	30		

Təsdiq	Açar	Xidmət Adı	Flg	Nəticə	Sənəd Status	Nəticə Qrupu	Modul	Min	Max	Qihaz Vəziyyəti	İzah
☒	☐	LDH*		207		Biokimya	U/L	135	214		
☒	☐	CA 19-9*		23,54		Onkomarker	U/mL	<	39		
☒	☐	CEA*		0,751		Onkomarker	U/mL	<	39		

Təsdiq	Açar	Xidmət Adı	Flg	Nəticə	Sənəd Status	Nəticə Qrupu	Modul	Min	Max	Qihaz Vəziyyəti	İzah
☒	☐	ALT*		24,3		Biokimya	U/L	<	41		
☒	☐	LDH*		158		Biokimya	U/L	135	225		
☒	☐	Kreatin kinaza (CK)	↑	314		Biokimya	U/L	39	308		

Figure 2. LDH analysis result panel

3. Pathophysiological analysis of LDH, ALT and isolated CK activity in young adulthood

The biochemical profile of a 25-year-old male patient in a high stage of biological activity was included in the analysis. In the patient's analysis, the liver-specific transferase enzyme (ALT) was recorded at 24.3 U/L, and the total LDH level was 158 U/L, which were completely within the optimal normative limits (reference: 135–225 U/L). However, in this patient's profile, it was determined that the muscle isoenzyme creatine kinase (CK) was 314 U/L, slightly exceeding the maximum reference norm of 308 U/L. This isolated CK increase, which occurred when the liver and general cellular damage markers were normal, is related to the acute physical activity or heavy sports stress in the patient's anamnesis. The stability of LDH, reflecting general cytoplasmic destruction, and ALT, indicating hepatocellular status, proves that this increase is not due to structural pathology, but is completely transient and functional muscle leakage related to physical exertion.

4. Comprehensive laboratory analysis of electrolyte balance and renal function in

a young female patient

To assess electrolyte regulation in young age, biochemical parameters of a 21-year-old female patient were reviewed. The patient's serum potassium level was determined to be 4.4 mmol/L, which was in the middle of the laboratory reference range (3.5–5.1 mmol/L), indicating an ideal homeostatic level (**Figure 3**). Although the total protein and albumin concentrations in other markers of this patient were normal, the levels of urea, which reflects the excretory function of the kidney, and parathyroid hormone (PTH), which regulates bone-mineral metabolism, sharply exceeded the maximum reference limits. Despite the transient overload of the kidney's filtration function and the tendency for nitrogen residues to accumulate in the blood, the potassium balance is under full control. The clinical picture shows that in a young organism, internal compensatory systems and the internal organization of cell membranes have a high functional reserve. As a result, even during renal filtration stress, the risk of life-threatening hyperkalemia is successfully prevented, and the potassium ion balance is maintained stably.

	Tasdiq	Açar	Xidmat Adı	Fig	Natıca	Sanaad Statusı	Natıca Grupu	Modul	Min	Max	Qıas Natıyısı	Sah
	☒	☐	K+*		4,75		Bıokımya	mmol/L	3,5	5,1	-	-
	☒	☐	TSH*		1,07		Hormonal mıs...	uIU/mL	0,27	4,2	-	-
	☒	☐	free T4*		1,47		Hormonal mıs...	ng/dL	0,9	1,7	-	-
	☒	☐	Anti-TPO		5,0		Hormonal mıs...	BU/mL	<	34	-	-

	Tasdiq	Açar	Xidmat Adı	Fig	Natıca	Sanaad Statusı	Natıca Grupu	Modul	Min	Max	Qıas Natıyısı	Sah
	☒	☐	Umumi zülal (qan)*		75,9		Bıokımya	g/L	66	87	-	-
	☒	☐	Albumin (qan)*		43,8		Bıokımya	g/L	35	52	-	-
	☒	☐	Sıdık cövhəri*	↑	12,9		Bıokımya	mmol/L	1,7	8,3	-	-
	☒	☐	K+*		4,55		Bıokımya	mmol/L	3,5	5,1	-	-
	☒	☐	Fosfor*		1,45		Bıokımya	mmol/L	0,81	1,45	-	-
	☒	☐	Parathormon*	↑	144,4		Hormonal mıs...	pg/mL	15	65	-	-

	Tasdiq	Açar	Xidmat Adı	Fig	Natıca	Sanaad Statusı	Natıca Grupu	Modul	Min	Max	Qıas Natıyısı	Sah
	☒	☐	Ca total (qan)*		2,25		Bıokımya	mmol/L	2,2	2,58	-	-
	☒	☐	K+*		4,57		Bıokımya	mmol/L	3,5	5,1	-	-
	☒	☐	Fe*		42,66		Bıokımya	ug/dL	27	150	-	-
	☒	☐	TSH*	↑	13,11		Hormonal mıs...	uIU/mL	0,27	4,2	-	-
	☒	☐	free T3*		2,84		Hormonal mıs...	pg/mL	2	4,4	-	-
	☒	☐	free T4*	↓	0,740		Hormonal mıs...	ng/dL	0,9	1,7	-	-
	☒	☐	Anti-TPO	↑	591,4		Hormonal mıs...	BU/mL	<	34	-	-

Figure 3. Potassium indicator analysis panel



The results of the conducted experimental study showed that hemolysis and lipemia, as the most important preanalytical interference factors in clinical laboratory diagnostics, significantly affect the determination of biochemical parameters, especially lactate dehydrogenase (LDH) activity and potassium ion concentration. In the study conducted at the Memorial Hospital clinical laboratory center, it was confirmed that these two factors cause systematic and quantitative deviations in laboratory results.

During hemolysis, disruption of the membrane integrity of erythrocytes has been observed to result in the free passage of intracellular LDH and potassium into the serum environment. Due to the significantly higher intracellular concentration compared to the extracellular environment, this leakage has led to an artificial increase in indicators and, in particular, to clinical interpretation errors (pseudo-hyperkalemia).

The kinetic indicators obtained within the framework of the study prove that the absorption rate changes in direct proportion to the increase in the degree of hemolysis and that the analytical bias exceeds critical limits.

Lipemia, on the other hand, increased light scattering in photometric measurements due to the increase in lipid and lipoprotein fractions (mainly chylomicrons and very low-density lipoproteins (VLDL) in plasma. This condition significantly reduced the accuracy of the results by creating optical interference in spectrophotometric analyses. In particular, in kinetic enzymatic measurements conducted at wavelengths of 340 nm and near it, the turbidity caused by lipid particles weakened the transmission of light to the sensors, minimizing the analytical sensitivity of the reactions.

The results of the study show that as the degree of hemolysis and lipemia

increases, the deviations in LDH and potassium indicators also increase in parallel; there is a statistically and pathophysiologically significant correlation ($p < 0.05$) between these changes. These factors directly increase the risk of making incorrect clinical decisions in the interpretation of laboratory results. Thus, strengthening sample quality control at the preanalytical stage, the application of automated serum indices (ASIs), and timely detection of hemolysis/lipemia are crucial in ensuring the reliability of laboratory diagnostics.

Conclusion and Recommendations

- **Preanalytical Standardization:** Laboratory management should fully standardize venipuncture, sample transport, and centrifugation steps.
- **Automated HIL Integration:** Subjective visual assessment should be eliminated, and the device-derived hemolysis (H) and lipemia (L) indices should be quantitatively measured for each sample.
- **Internal Quality Control:** Multi-step control programs based on Westgard rules should be implemented, especially in potassium and LDH assays, which are extremely sensitive to hemolysis.
- **Clinical Correlation:** In isolated marker elevations (e.g., a slight increase in CK in the presence of normal LDH or an increase in urea in the presence of normal potassium), the patient's physical history and compensatory mechanisms should be taken into account.

The factors that most affect the objectivity and reliability of test results in clinical laboratory diagnostics are hemolysis and lipemia, which are critical defects of the preanalytical stage. Statistics show that more

than 60% of the reasons for rejection of unsuitable blood samples are related to these interferences. The main aim of this study is to investigate the quantitative deviations and optical interference mechanisms caused by hemolysis and lipemia in spectrophotometric and potentiometric measurements, to evaluate the purification methods (centrifugation and chemical methods) that eliminate these lipid and hemoglobin barriers, and to analyze the dynamics of lactate dehydrogenase (LDH) and potassium ions in different age and gender groups in parallel with specific markers.

In a 3.5-year-old pediatric patient, LDH levels (297 U/L), somatotrophic hormone (1.41 ng/mL), and Vitamin B12 (575.8 pg/mL) were in physiological harmony with the indicators, reflecting an intensive anabolic process. In a 25-year-old young male patient, an isolated CK elevation (314 U/L) recorded against a background of normal LDH and ALT proved not to be structural damage, but a transient functional muscle leak due to physical exertion. In a 21-year-old female patient, despite the filtration stress caused by high urea and PTH levels, the constant potassium ion level (4.4 mmol/L) confirmed the pathophysiological stabilization of the cell membrane. Experimental analyses have shown that as the degree of hemolysis increases, in vitro false LDH and potassium (pseudo-hyperkalemia) elevations occur due to leakage of intracellular analytes, and optical light scattering and volume shift errors in lipemia lead to systematic deviations. In overcoming this lipid barrier, microcentrifugation and 4%-8% PEG concentrations were found to be effective alternatives in restoring the accuracy of routine analytes, while ultracentrifugation retained its advantage in small VLDL particles.

In conclusion, age-specific physiological adaptations must be taken into

account when interpreting laboratory results in different age groups. To ensure the reliability of laboratory diagnostics, subjective visual inspection should be eliminated, automated serum indices (ASIs) and spectral absorption corrections should be integrated, and each laboratory should validate the analytical working principles of individual analyzer platforms with internal quality control programs.

Acknowledgement

The authors gratefully acknowledge Memorial Hospital for providing the laboratory facilities and support for data analysis that contributed to this study.

Conflict of Interest

The authors declare that there is no conflict of interest.

References

- Alkhatib A.J. (2019) Lactate dehydrogenase: Physiological roles and clinical implications. *Am J Biomed Sci & Res.*, 3(5):415–416. Doi: [10.34297/AJBSR.2019.03.000705](https://doi.org/10.34297/AJBSR.2019.03.000705)
- Atay A., Demir L., Cuhadar S., Saglam G., Unal H., Aksun S., Arslan B., Ozkan A., Sutcu R. (2014) Clinical biochemistry laboratory rejection rates due to various types of preanalytical errors. *Biochem Med (Zagreb)*, 15;24(3):376–382. Doi: [10.11613/BM.2014.040](https://doi.org/10.11613/BM.2014.040).
- Berman M.H., Hayes J.C. (2024) A-119 Lipemia Interference. *Clinical Chemistry*, 70(Supplement 1). Doi: [10.1093/clinchem/hvae106.118](https://doi.org/10.1093/clinchem/hvae106.118)
- Calmarza P., Cordero J. (2011) Lipemia interferences in routine clinical biochemical tests. *Biochem Med (Zagreb)*, 21:160–166.
- Farhana A., Lappin S.L. (2021) Biochemistry, Lactate dehydrogenase. [Updated 2023 May 1]. In: StatPearls



- [Internet]. Treasure Island (FL): StatPearls Publishing; 2026 Jan. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK557536/>
- Hebert S.C., Desir G., Giebisch G., Wang W. (2005) Molecular diversity and regulation of renal potassium channels. *Physiol Rev.*, 85(1):319–371. Doi: [10.1152/physrev.00051.2003](https://doi.org/10.1152/physrev.00051.2003)
- Li X., Yang Y., Zhang B., Lin X., Fu X., An Y., Zou Y., Wang J.X., Wang Z., Yu T. (2022) Lactate metabolism in human health and disease. *Signal Transduct Target Ther.*, 7(1):305. Doi: [10.1038/s41392-022-01151-3](https://doi.org/10.1038/s41392-022-01151-3)
- Lippi G., Luca Salvagno G., Blanckaert N., Giavarina D., Green S., Kitchen S., Palicka V., Vassault A.J., Plebani M. (2009) Multicenter evaluation of the hemolysis index in automated clinical chemistry systems. *Clin Chem Lab Med.*, 47(8):934–939. Doi: [10.1515/CCLM.2009.218](https://doi.org/10.1515/CCLM.2009.218)
- Lippi G., Cadamuro J., von Meyer A., Simundic A.M. European Federation of Clinical Chemistry and Laboratory Medicine (EFLM) Working Group for Preanalytical Phase (WG-PRE). (2018) Practical recommendations for managing hemolyzed samples in clinical chemistry testing. *Clin Chem Lab Med.*, 56(5):718–727. Doi: [10.1515/cclm-2017-1104](https://doi.org/10.1515/cclm-2017-1104)
- McDonough A.A., Youn J.H. (2017) Potassium Homeostasis: the knowns, the unknowns, and the health benefit. *Physiology (Bethesda)*, 32(2):100–111. Doi: [10.1152/physiol.00022.2016](https://doi.org/10.1152/physiol.00022.2016)
- Nikolac N. (2014) Lipemia: causes, interference mechanisms, detection and management. *Biochem Med (Zagreb)*, 24(1):57–67. Doi: [10.11613/BM.2014.008](https://doi.org/10.11613/BM.2014.008)
- Salvagno G.L., Demonte D., Lippi G. (2019) A paradigmatic case of haemolysis and pseudohyperkalemia in blood gas analysis. *Biochem Med (Zagreb)*, 29(1):011003. Doi: [10.11613/BM.2019.011003](https://doi.org/10.11613/BM.2019.011003)
- Schlüter K., Cadamuro J. (2023) Erroneous potassium results: preanalytical causes, detection, and corrective actions. *Crit Rev Clin Lab Sci.*, 60(6):442–465. Doi: [10.1080/10408363.2023.2195936](https://doi.org/10.1080/10408363.2023.2195936)
- Tang L., Yang Q., Ma R., Zhou P., Peng C., Xie C., Liang Q., Wu T., Gao W., Yu H., Deng G., Dai Z., Mao N., Xiao X. (2024) Association between lactate dehydrogenase and the risk of diabetic kidney disease in patients with type 2 diabetes. *Front Endocrinol (Lausanne)*, 15:1369968. Doi: [10.3389/fendo.2024.1369968](https://doi.org/10.3389/fendo.2024.1369968)
- Unwin R., Alain D., Gilles C. (2015) Potassium homeostasis. In Robert Unwin (ed.), The Patient with fluid, electrolyte, and renal tubular disorders, in Neil N. Turner and others (eds.), Oxford Textbook of Clinical Nephrology: Three-Volume Pack, 4th edn.; Oxford. Doi: [10.1093/med/9780199592548.003.0023](https://doi.org/10.1093/med/9780199592548.003.0023)
- Wu Y., Lu C., Pan N., Zhang M., An Y., Xu M., Zhang L., Guo Y., Tan L. (2021) Serum lactate dehydrogenase activities as systems biomarkers for 48 types of human diseases. *Sci Rep.*, 11(1):12997. Doi: [10.1038/s41598-021-92430-6](https://doi.org/10.1038/s41598-021-92430-6)
- Zhou Y., Qi M., Yang M. (2022) Current status and future perspectives of lactate dehydrogenase detection and medical implications: a review. *Biosensors (Basel)*, 12(12):1145. Doi: [10.3390/bios12121145](https://doi.org/10.3390/bios12121145)



ANTHROPOZOONOTIC DISEASES, DIAGNOSTICS AND TREATMENT METHODS

Sabina Elman Kazimli 

Department of Natural Sciences, Western Caspian University, AZ1072, Baku, Azerbaijan

Abstract: Anthropozoonoses are a group of infectious diseases transmitted from animals to humans and of significant epidemiological and social importance for both human and animal health. The causative agents of these diseases can be various pathogenic microorganisms, including bacteria, viruses, fungi, and helminths. Wild, semi-wild and domestic animals play an important reservoir role in the spread of zoonotic infections. Depending on the characteristics of the pathogen and the direction of transmission, zoonoses are divided into bacterial, viral, mycotic and helminthic groups, as well as amphixenosis, anthropozoonosis and zooanthroposes. Human infection with anthropozoonoses occurs mainly as a result of direct contact with sick or carrier animals, contact with biological materials during veterinary and diagnostic examinations, examination of sick animal carcasses, as well as the use of infected food and other products of animal origin. Diseases such as brucellosis, tuberculosis, anthrax, listeriosis and rabies are important examples of anthropozoonoses. In the prevention of these diseases, identification of sources of infection among animals, epidemiological surveillance, early diagnosis, and prevention of the chain of infection between humans and animals are of great importance.

Keywords: anthrax, brucellosis, salmonellosis, tuberculosis, tularemia.

***Corresponding author:** sabinammmmdova922@gmail.com

Received: 1 September 2026 Accepted: 8 September 2026 Published: 18 September 2026

DOI: 10.54414/TNEL1688

Introduction

Anthropozoonotic diseases are a group of infectious diseases that can be transmitted from animals to humans and, in some cases, from humans to animals in natural conditions. These diseases are of significant epidemiological importance for human and animal health, and their causative agents can be bacteria, viruses, fungi, and parasites. In the spread of anthropozoonoses, various domestic and wild animal species, including dogs, cats, birds, sheep, cattle, rodents, and other mammals, can act as a source or

reservoir of infection (Bell et al. 1988).

Depending on the biological characteristics of the agent, the transmission of infection to humans occurs in various ways, mainly through direct and indirect contact, inhalation, and the alimentary route. Salmonellosis, brucellosis, leptospirosis, campylobacteriosis, rabies, Lyme disease, plague, tularemia, sporotrichosis, dermatophytosis, echinococcosis, cysticercosis, and toxoplasmosis are examples of anthropozoonotic diseases.

Identifying sources of infection, controlling transmission routes, regular veterinary examinations of animals, vaccination, parasite control, and sanitary and hygienic measures play an important role in preventing these diseases. Timely vaccination of animals is one of the main methods of preventing the spread of the disease, especially in the prevention of serious zoonoses such as rabies (Azərbaycan Milli Ensiklopediyası 2009; Wilson 2014).

Anthroozoonotic Disease Agents ***Bacteria and Viruses***

A significant part of anthroozoonoses is associated with infections of bacterial and viral origin. Bacteria play an important role in the spread of zoonoses by causing various infectious processes in the human and animal body. One of the main features of bacterial anthroozoons is that they can exist for a long time in various animal species and that these animals act as a source or reservoir of infection. Infection in humans occurs mainly through direct contact with sick or bacteria-carrying animals, ingestion of animal-derived food products, contact with infected materials, and in some cases through the respiratory tract. Brucellosis, salmonellosis, campylobacteriosis, leptospirosis, plague, and tularemia are examples of bacterial zoonoses. In preventing the spread of these diseases, veterinary control of animals, identification of infected animals, sanitary measures, and vaccination against some infections are of great importance (Göker & Oren 2024).

Viral zoonoses, on the other hand, arise as a result of the transmission of viruses between animals and humans, and their spread characteristics depend on the biological characteristics of the causative agent, reservoir, and transmission mechanism. In viral zoonoses, wild and domestic animals can be natural reservoirs or sources of infection for viruses. Infection

in humans can occur through direct contact, animal bites, respiratory, alimentary, and, in some cases, vectors. Rabies is an important example in this regard and is mainly transmitted as a result of contact with the bite or saliva of an infected animal. Some zoonotic influenza viruses can be transmitted from animals to humans through the respiratory tract. The main difference between bacterial and viral anthroozoonoses is manifested in the biological characteristics of their causative agents, as well as their maintenance in animals, mechanisms of transmission to humans, and preventive approaches. Therefore, the identification of the source of infection, transmission route, and risk factors for each anthroozoonotic disease is one of the main conditions for preventing the spread of the disease (Breitbart & Rohwer 2005).

Parasites and Fungi

Parasitic anthroozoonoses are diseases caused by parasites using human and animal organisms as a food and living environment. The causative agents of these diseases are mainly helminths, protozoa, and various arthropods. Animals can participate in the spread of parasitic anthroozoonoses as primary or intermediate hosts. The complex life cycle of some parasites requires the use of two or more hosts to complete their development. Human infection can occur through contact with infected animals, ingestion of contaminated food and water, as well as the participation of ticks and other arthropods. Some arthropods play the role of vectors in the transmission of parasites and other pathogens from one host to another. This feature is of great importance in distinguishing parasitic anthroozoonoses from other infections. Echinococcosis, toxoplasmosis, cysticercosis, and other parasitic diseases can be attributed to this group (Ələsgərov 2016).



Fungal anthropozoonoses are characterized by fungi causing infections in humans and animals and transmission from animals to humans. The main source of infection in these diseases can be sick animals or fungal carriers. Human infection occurs mainly as a result of direct contact with sick animals and contact with their hair, skin, and other infected materials. Dermatophytosis is an example of fungal zoonoses that can be transmitted from animals to humans. Unlike parasitic anthropozoonoses, the main transmission mechanism in fungal infections is often associated with direct contact between infected animals and humans. Therefore, early identification of sick animals, veterinary control, compliance with hygiene rules, and limiting contact with infected animals play an important role in the prevention of fungal anthropozoonoses (Arora 1986).

Anthropozoonotic Diseases

Anthrax

Anthrax is an acute zoonotic infectious

disease that affects both humans and animals and is caused by the bacterium *Bacillus anthracis*. The causative agent is a Gram-positive, rod-shaped, spore-forming bacterium whose spores are highly resistant to environmental conditions and can remain viable in soil for long periods. Humans are mainly infected through contact with infected or dead animals, contaminated soil, or contaminated animal products. The bacterium can enter the body through damaged skin and mucous membranes, as well as through the digestive and respiratory tracts. In humans, anthrax occurs mainly in cutaneous, pulmonary, and gastrointestinal forms, with the cutaneous form being the most common. Diagnosis is based on clinical and epidemiological findings, together with laboratory tests. Treatment primarily involves appropriate antibiotic therapy (Hendricks et al. 2014). Preventive measures include veterinary surveillance, early identification of infected animals, proper sanitation and hygiene, and avoiding contact with contaminated materials (Figure 1).

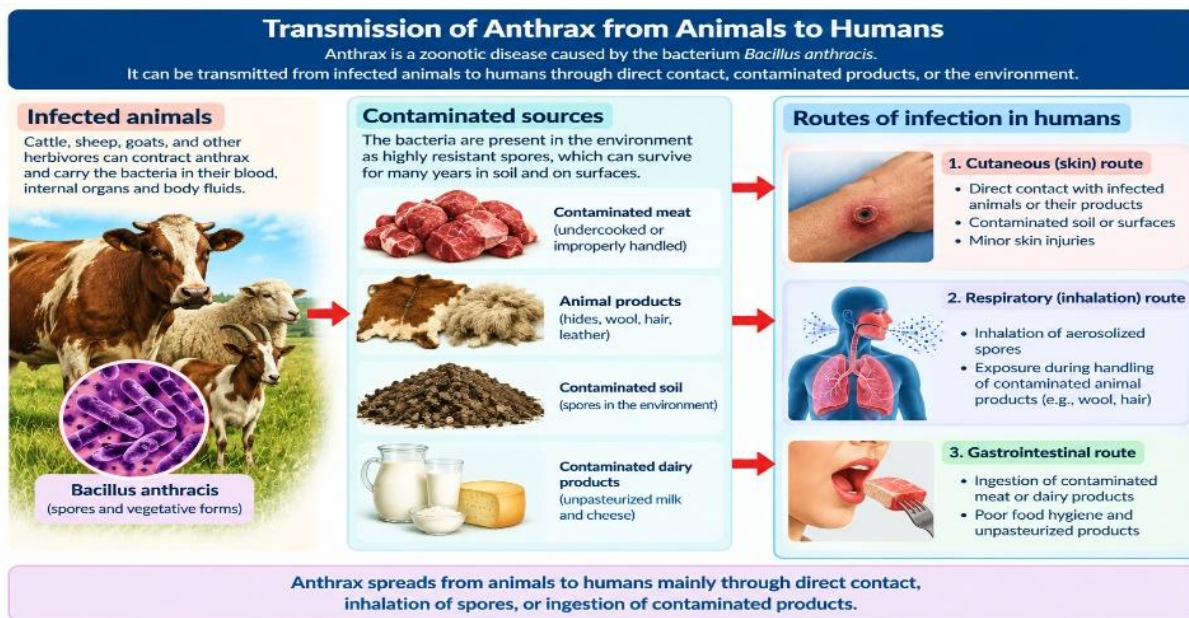


Figure 1. Transmission of anthrax disease.

Tuberculosis

Tuberculosis (TB) is a chronic infectious disease characterized by the formation of specific nodules called tubercles in various organs and tissues. The main causative agent is *Mycobacterium tuberculosis*, although different species of mycobacteria can cause infection in humans and animals. Tuberculosis primarily affects the lungs but can also spread to other organs and tissues. The pathogen mainly enters the human body through aerosol and alimentary routes, causing pathological changes in the lung tissue, lymphatic system, and other organs.

Tuberculosis is of significant epidemiological importance for livestock, wild animals, birds, and humans. *M. bovis* plays an important role in tuberculosis infections of animal origin. Diagnosis is based on clinical and epidemiological data, as well as allergic tests, histological examinations, and bacteriological tests. Treatment is based on long-term antimicrobial therapy. Early diagnosis, identification of infected individuals, and

effective epidemiological surveillance are essential for the prevention and control of tuberculosis (Azərbaycan Milli Ensiklopediyası 2009; Ələsgərov 2016).

Brucellosis

Brucellosis is a predominantly chronic zoonotic infectious disease that affects both humans and animals. It is caused by small, pleomorphic bacteria belonging to the genus *Brucella*. The main source of infection is infected animals, and the pathogen can spread into the environment, particularly through milk and other bodily secretions. Humans are mainly infected through contact with infected animals and consumption of raw milk, dairy products, or contaminated meat. The pathogen can also enter the body through damaged skin and mucous membranes. The risk of infection is particularly high among people who have close contact with sheep and goats. Common symptoms include high fever, headaches, muscle and joint pain, night sweats, weakness, weight loss, and other systemic manifestations (Figure 2).

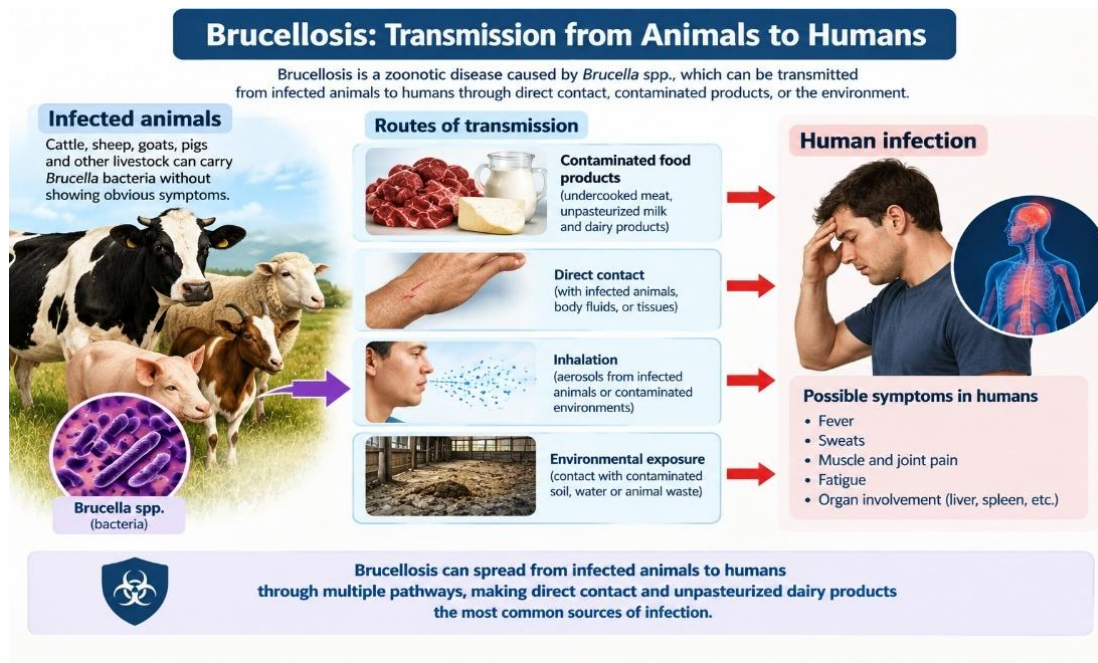


Figure 2. Infectious period of Brucellosis.



Diagnosis of brucellosis is based on epidemiological and clinical findings, as well as bacteriological, serological, and allergic diagnostic methods. Prevention includes veterinary monitoring of animals, vaccination, maintaining good personal hygiene, and avoiding the consumption of raw animal products. Brucellosis is an important zoonotic disease that can have significant epidemiological and economic effects on both human health and livestock production (Di Pierdomenico et al. 2011).

Tularemia

Tularemia is a naturally occurring, acute anthropozoonotic infectious disease. It is caused by the bacterium *Francisella tularensis*. Humans can become infected mainly through tick and other blood-sucking insect bites, contact with infected animals, or consumption of contaminated water and food. The pathogen can also enter the body through damaged skin, the respiratory tract, and the digestive tract. The incubation period usually lasts 3–7 days. The main clinical symptoms include high fever, chills, headache, muscle pain, weakness, loss of appetite, and enlarged lymph nodes. Depending on the route of infection, the lymph nodes, pharynx, bronchi, and lungs may be affected. Diagnosis is based on epidemiological and clinical findings, together with bacteriological, serological, and allergy-based tests. Treatment involves appropriate antibiotic therapy, while prevention focuses on reducing exposure to sources of infection and disease vectors (Azərbaycan Milli Ensiklopediyası 2009; Ələsgərov 2016).

Conflict of Interest

The authors declare that there is no conflict of interest.

References

Azərbaycan Milli Ensiklopediyası (25

- cildə). 1-ci cild: A – Argelander (2009) Bakı: "Azərbaycan Milli Ensiklopediyası" Elmi Mərkəzi. 608 s.
- Arora D. (1986) Mushrooms demystified: a comprehensive guide to the fleshy fungi.
- Ələsgərov Z.A. (2016) Antropozoonoz xəstəliklər. Bakı, Elm, 520 s.
- Bell J.C., Palmer S.R., Payne J.M. (1988) The zoonoses: infections transmitted from animals to man (pp. xi+241pp).
- Breitbart M., & Rohwer F. (2005) Here a virus, there a virus, everywhere the same virus? *Trends in microbiology*, 13(6), 278–284. [Doi: 10.1016/j.tim.2005.04.003](https://doi.org/10.1016/j.tim.2005.04.003)
- Di Pierdomenico A., Borgia S. M., Richardson D., Baqi M. (2011) Brucellosis in a returned traveller. *Canadian Medical Association Journal*, 183(10), E690-E692. [Doi: 10.1503/cmaj.091752](https://doi.org/10.1503/cmaj.091752)
- Göker M., & Oren A. (2024) Valid publication of names of two domains and seven kingdoms of prokaryotes. *International journal of systematic and evolutionary microbiology*, 74(1), 006242.b
- Hendricks K.A., Wright M.E., Shadomy S.V., Bradley J.S., Morrow M.G., Pavia A.T., Bower W.A. (2014) Centers for Disease Control and Prevention expert panel meetings on prevention and treatment of anthrax in adults. *Emerging Infectious Diseases*, 20(2), e130687.
- Wilson E.O. (2014) The meaning of human existence. WW Norton & Company. 112 p.

**Journal of Endemism:
biodiversity & environment
VOL 4, No 3
September 2026**

Polygraphy: Balabaji Nasir Javadova

*The editors are not responsible for the facts and the position of the author in the published materials.
The author himself is responsible for the scientific thoughts in the work. When
using materials, it's necessary to provide a link and the DOI of the journal.*

Editorial address: 17A, Ahmad Rajabli str., III

Parallel, Baku, Azerbaijan, AZ1072

Phone: +994 12 565 39 74

E-mail: endemism_science@wcu.edu.az

www.ebe.wcu.edu.az

The date of collection: 14.09.2026

Signed for printing: 15.09.2026

Paper format: 60x84 1/16 17