ISNN 3030-3907

2026/2
VOLUME 4

DEVELOPMENT OF SCIENCE

ILMIY JURNAL



Development of science

Ilmiy jurnal

2026/2 VOLUME 4

ISSN 3030 -3907

Ilmiy jurnal OAK rayosatining 2024 yil 27 sentabrdagi 361-son qaroriga asosan 02.00.00 kimyo fanlari hamda 2025 yil 12 fevral 367- son qaroriga asosan 05.00.00 texnika fanlari bo‘yicha falsafa doktori (PhD) va fan doktori (DSc) ilmiy darajasiga talabgorlarning dissertatsiya ishlari yuzasidan dissertatsiyalari asosiy ilmiy natijalarini chop etish tavsiya etilgan milliy ilmiy nashrlar ro‘yxatiga kiritilgan.

BOSH MUHARRIR:
Temirov Alisher Hoshim o‘g‘li – texnika fanlari falsafa doktori (PhD),Dotsent.
TAHRIRIYAT KENGASH RAISI:
Fozilov Sadriddin Fayzullayevich – texnika fanlari doktori, professor
TAHRIRIYAT KENGASH A’ZOLARI

TEXNIKA FANLARI/ TECHNICAL SCIENCES/ ТЕХНИЧЕСКИЕ НАУКИ

Bozorov G‘ayrat Rashidovich
Buxoro Davlat Texnika Universiteti, professor
Abdurahmonov Olim Rustamovich
Buxoro Davlat Texnika Universiteti, professor
Adizov Bobur Zamirovich
O‘zbekiston Respublikasi Fanlar akademiyasi Umumiy va noorganik kimyo instituti, professor
Hayitov Ruslan Rustamjonovich
Buxoro Davlat Texnika Universiteti, professor
Jumayev Qayum Karimovich
Buxoro Davlat Texnika Universiteti, professor.
Berdiyev Dorob Murodovich
Islom Karimov nomidagi Toshkent Davlat Texnika Universiteti, professor
Maxmudov Rafiq Amonovich
Buxoro Davlat Texnika Universiteti, professor.
Tilloyev Lochin Ismatilloyevich
Buxoro Davlat Texnika Universiteti, dotsent.
Raxmonov Qahramon Sanakulovich
Buxoro Davlat Texnika Universiteti, dotsent.
Barakayev Nusratullo Rajabovich
Islom Karimov nomidagi Toshkent Davlat Texnika Universiteti, professor.
Jo‘rayev Xayrullo Fayziyevich
Buxoro Davlat Texnika Universiteti, professor.
Panoyev Erali Rajabboyevich
Buxoro Davlat Texnika Universiteti, dotsent.
Ataullayev Sherzod Nabiullyevich
Buxoro Davlat Texnika Universiteti, dotsent.
Murodov Malik Negmurodovich
Buxoro Davlat Texnika Universiteti, dotsent.
Axmedova Ozoda Bahronovna
Islom Karimov nomidagi Toshkent Davlat Texnika Universiteti.
Safarov Bahri Jumayevich
Buxoro Davlat Texnika Universiteti, dotsent.
Xaydarov Axtam Amonovich
Buxoro Davlat Texnika Universiteti, dotsent.
Safarov Jasur Alijon o‘g‘li
Buxoro Davlat Texnika Universiteti, dotsent.

KIMYO FANLARI/ CHEMICAL SCIENCES/ ХИМИЧЕСКИЕ НАУКИ

Axmedov Voxid Nizomovich
Buxoro Davlat Texnika Universiteti, professor
Umarov Baqo Bafoyevich
Buxoro Davlat Universiteti, professor
Kodirov Abduaxad Abduraximovich
Qarshi davlat Universiteti, professor
Qurbonov Mingniqul Jumagulovich
Qarshi davlat Universiteti, dotsent
Turemuratov Sharibay Naurizbaevich
O‘zbekiston Respublikasi Fanlar akademiyasi Qoraqalpog‘iston bo‘limi Bosh ilmiy kotibi, professor
Tursunov Kaxor Shonazarovich
Qarshi davlat Universiteti, professor
Do‘stov Hamro
Buxoro Davlat Texnika Universiteti, professor
Panoyev Nodir Shavkatovich
Buxoro Davlat Texnika Universiteti, dotsent.
Olimov Bobur Bahodir o‘g‘li
Buxoro Davlat Texnika Universiteti, dotsent.
Kasimov Sherzod Abduazimovich
Termiz Davlat Universiteti, professor.
Aliqulov Rustam Valiyevich
Termiz Davlat Universiteti, professor
Tropov Xamza Tursunovich
Samarqand Davlat Universiteti, professor

IQTISODIYOT FANLARI/ ECONOMICS/ ЭКОНОМИЧЕСКИЕ НАУКИ

Nizamov Aslitdin Badreddinovich
Buxoro Davlat Texnika Universiteti, professor.
Boboyev Akmal Choriyevich
Buxoro Davlat Texnika Universiteti, professor.
Ergashxojayeva Shaxnoza Djasurovna
Toshkent davlat iqtisodiyot universiteti, professor
Saidaxmedova Nodira Ilxomovna
Toshkent davlat iqtisodiyot universiteti, professor
Muxsinov Bekzod Toxirovich
Buxoro Davlat Texnika Universiteti, dotsent.
Shakarov Qulmat Ashirovich
Renessans ta'lim universiteti,dotsent.
Jumaeva Zulfiya Qayumovna
Buxoro Davlat Texnika Universiteti, dotsent.
Norova Salomat Yusupovna
Buxoro Davlat Texnika Universiteti, dotsent.
Avezova Shaxnoza Maxmudjonovna
Buxoro Davlat Texnika Universiteti, dotsent.
Jalilov Jamshid G‘anijonovich
Toshkent davlat iqtisodiyot universiteti, dotsent
Xasanova Gulruh Djumanazarovna
Buxoro Davlat Texnika Universiteti, dotsent.

PEDAGOGIKA FANLARI/ PEDAGOGICAL SCIENCES / ПЕДАГОГИЧЕСКИЕ НАУКИ

Siddiqova Sadoqat G‘afforovna
Buxoro Davlat Texnika Universiteti, dotsent.
Zoyirov Erkin Xalilovich
Buxoro Davlat Texnika Universiteti, DSc, professor
Gaffarov Feruz Hasanovich
Puchon Universiteti, *professor*
Ruziyev Davron Yuldashevich
Buxoro Davlat Universiteti, professor
Muradova Firuza Rashidovna
Buxoro Davlat Texnika Universiteti, professor.
Yunusova Gulandon Samiyevna
Buxoro Davlat Texnika Universiteti, professor.
To‘xtayeva Zebo Sharifovna
Buxoro Davlat Texnika Universiteti, professor.
Navro‘zova Gulchixra Nigmatovna
Buxoro Davlat Texnika Universiteti, dotsent.
Uzoqova Laylo Polvonovna
Buxoro muhandislik – texnologiya instituti, dotsent.
To‘raqulova Marjona Qiyom qizi
Buxoro Davlat Texnika Universiteti, dotsent.
Muradova Zarina Rashidovna
Buxoro Davlat Texnika Universiteti, dotsent.
Murodov Sanjar Aslonovich
Buxoro Davlat Texnika Universiteti, dotsent.
Shodiyev Jahongir Jo‘raqulovich
Buxoro Davlat Texnika Universiteti, dotsent
Gaffarov Laziz Hasanovich
Buxoro muhandislik – texnologiya instituti, dotsent.

Tahririyat a’zolarning to‘liq ro‘yxati jurnalning www.devos.uz saytida keltirilgan.

Tahririyat hay’ati a’zolarining tarkibini o‘zgartirish hamda qo‘shimcha kiritish yoki tahririyat a’zoligidan chiqarish bosh muharrir tomonidan amalga oshiriladi.

ISSN 3030-3907

Development of science ilmiy jurnali 2024 yil 15 aprel kuni №256445 sonli guvohnoma bilan Davlat ro‘yxatidan o‘tgan.

To‘plam elektron ko‘rinishda (pdf formatida) mualliflarga taqdim etiladi. To‘plamga kiritiladigan maqolalarning mazmuni, ulardagi statistik ma’lumotlar va me’yoriy hujjatlarning to‘g‘riligiga hamda har qanday fikr - mulohazalarga mualliflarning o‘zlari mas’ul hisoblanadilar. Talablarga javob bermaydigan maqolalar to‘plamga kiritilmaydi. Tashkiliy qo‘mita maqola matnini qisqartirish, qisman tuzatish kiritish, seksiyalarga joylashtirish huquqiga ega.

ISSN 3030-3907

“SURVIVAL ENGINEERING IN TERMITES: THE LIVING ENVIRONMENT OF ANACANTHOTERMES AHNGERIANUS ACROSS SEASONS”

Akbarov Ilyos Farhod o'g'li

Central Asian University, 264 Milliy, bog St, 111221, Tashkent, Tashkent

Abstract. *Anacanthotermes ahngerianus* is a dominant subterranean “lower termite” of Central Asia that thrives across desert–semi-desert ecosystems and readily expands into irrigated and urban habitats, where it becomes a major structural pest. This review synthesizes current knowledge on the “survival engineering” of *A. ahngerianus*—the integrated set of nest-building, microclimate regulation, seasonal behavioral shifts, foraging-network dynamics, and gut symbioses that together enable persistence under sharply continental climates with extreme temperature–humidity variability. We summarize its habitat envelope and diagnostic ecological signs, then examine nest architecture as a soil–organic composite engineered by worker construction that buffers heat and desiccation. Seasonal ecology is discussed as a vertical and horizontal reconfiguration of activity: colony functions and foraging intensify during spring and autumn, while heat and aridity constrain near-surface activity in summer and push movement deeper in winter. We review resource acquisition via extensive subterranean galleries guided by chemical communication, highlighting how behavioral plasticity supports exploitation of both natural cellulose sources and anthropogenic wood materials. A dedicated section evaluates symbiosis-driven digestion (protozoa–bacteria consortia), trophallaxis-mediated symbiont maintenance, and their implications for colony nutrition in nitrogen-poor environments. Finally, we connect behavioral ecology to management: why concealed nesting reduces efficacy of surface treatments, how trophallaxis favors bait-based strategies, and which knowledge gaps (demography, dispersal, climate-linked forecasting, species-specific monitoring) most limit evidence-based control.

Key words: *Anacanthotermes ahngerianus*; subterranean termites; nest architecture; microclimate regulation; seasonal ecology; foraging tunnels; gut microbiome symbiosis; integrated termite management (IPM)

Аннотация. *Anacanthotermes ahngerianus* — доминирующий подземный «низший термит» Центральной Азии, успешно обитающий в пустынно-полупустынных экосистемах и легко распространяющийся в орошаемые и городские местообитания, где становится одним из основных структурных вредителей. Настоящий обзор обобщает современные знания о «инженерии выживания» *A. ahngerianus* — интегрированном комплексе строительства гнезда, регуляции микроклимата, сезонных поведенческих сдвигов,

ISSN 3030-3907

динамики кормодобывающих сетей и кишечных симбиозов, которые в совокупности обеспечивают устойчивость вида в условиях резко континентального климата с экстремальной изменчивостью температуры и влажности. Мы суммируем его экологическую нишу и диагностические экологические признаки, затем рассматриваем архитектуру гнезда как почвенно-органический композит, создаваемый рабочими и обеспечивающий буферирование перегрева и иссушения. Сезонная экология обсуждается как вертикальная и горизонтальная перестройка активности: функции колонии и фуражировка усиливаются весной и осенью, тогда как жара и аридность ограничивают приповерхностную активность летом и смещают перемещения глубже зимой. Рассматривается добывание ресурсов посредством разветвлённой сети подземных ходов, направляемой химической коммуникацией; подчёркивается, что поведенческая пластичность поддерживает освоение как природных целлюлозных источников, так и антропогенных древесных материалов. Отдельный раздел посвящён симбиоз-обусловленному пищеварению (консорциум простейших и бактерий), поддержанию симбионтов через трофаллаксис и их значению для питания колонии в бедных азотом средах. В заключение связываем поведенческую экологию с практикой управления численностью: почему скрытое гнездование снижает эффективность поверхностных обработок, как трофаллаксис повышает результативность приманочных стратегий и какие пробелы знаний (демография, расселение, климат-связанное прогнозирование, видоспецифический мониторинг) наиболее ограничивают доказательно обоснованный контроль.

Ключевые слова: *Anacanthotermes ahngerianus*; подземные термиты; архитектура гнезда; регуляция микроклимата; сезонная экология; кормовые (фуражировочные) ходы; симбиоз кишечного микробиома; интегрированная защита/управление численностью термитов (IPM).

Annotatsiya. *Anacanthotermes ahngerianus* — Markaziy Osiyoda mavjud bo’lgan yer ostida yashovchi “quyi termit” bo‘lib, cho‘l, yarim cho‘l ekotizimlarida muvaffaqiyatli yashaydi va sug‘oriladigan hamda shahar hududlariga oson kengayib, u yerda yirik konstruktiv (inshoot) zararkunandasiga aylanadi. Ushbu maqolada *A. ahngerianusning* “tirik qolish injiniringi” bo‘yicha mavjud bilimlarni umumlashtiradi: bunda uya qurish, mikroiqlimni boshqarish, mavsumiy xulq-atvor, oziqlanish tarmog‘i dinamikasi va ichak simbiozlaridan iborat integratsiyalashgan tizim bo‘lib, keskin kontinental iqlim sharoitida (harorat va namlikning keskin tebranishlarida) barqaror saqlanib qolishni ta’minlaydi. Biz uning yashash muhiti doirasi va diagnostik ekologik belgilarini qisqacha bayon

ISSN 3030-3907

qilamiz, so‘ng ishchi termitlar tomonidan quriladigan, issiqlik va qurishdan himoya qiluvchi “tuproq–organik kompozit” sifatidagi uya arxitekturasini tahlil qilamiz. Mavsumiy ekologiya faoliyatning vertikal va gorizontal qayta tashkil topishi sifatida muhokama qilinadi: koloniya funksiyalari va oziqlanish faolligi bahor va kuzda kuchayadi, yozda esa issiq va qurg‘oqchilik yer yuzasiga yaqin faollikni cheklaydi, qishda esa harakat chuqurroq qatlamlarga siljiydi. Biz kimyoviy kommunikatsiya tomonidan yo‘naltiriladigan keng yer osti galeriyalari orqali resurslarni egallashni ko‘rib chiqamiz hamda xulq-atvor plastikliklari tabiiy sellyuloza manbalari bilan bir qatorda antropogen yog‘och materiallardan ham foydalanishni ta’minlashini ta’kidlaymiz. Alohida bo‘limda simbiozga asoslangan hazm jarayoni (protozoyalar–bakteriyalar konsorsiumi), trofallaksis orqali simbiotlarni saqlab turish va ularning azotga kambag‘al muhitlarda koloniya oziqlanishi uchun ahamiyati baholanadi. Yakunda xulq-atvor ekologiyasini boshqaruv (kurash) bilan bog‘laymiz: nega yashirin uya qurish yuzaki ishlov berish usullarining samaradorligini pasaytiradi, qanday qilib trofallaksis yem (bait)ga asoslangan strategiyalarni qo‘llab-quvvatlaydi va qaysi bilim bo‘shliqlari (demografiya, tarqalish, iqlimga bog‘liq prognozlash, turga xos monitoring) dalillarga asoslangan nazoratni eng ko‘p cheklaydi.

Kalit so‘zlar: *Anacanthotermes ahngerianus*; yer osti termitlari; uya arxitekturasi; mikroiqlimni boshqarish; mavsumiy ekologiya; oziqlanish tunnellari; ichak mikrobiomi simbiozi; termitlarni integratsiyalashgan boshqaruv (IPM).

INTRODUCTION

Termites cause major economic damage globally and in buildings, heritage structures. Their hidden lifestyle and protected nesting make control difficult. Abdullaev (2016) reported that a colony occupying roughly 100 cm^3 and containing about 25,000 individuals can consume, over one year, approximately 50,000 cm^3 of cellulose in various forms. In Uzbekistan, the termite fauna reported in the scientific literature is dominated by two native “Lower termites” of the genus Anacanthotermes: *Anacanthotermes turkestanicus and Anacanthotermes ahngerianus* which are described as widespread across desert, irrigated agricultural, and even urban settings, while recent studies have expanded the national list by documenting higher termites such as *Amitermes rhizophagus* and reports of *Microcerotermes turkmenicus* from Uzbekistan (Togaev U et al.,2025), indicating that the country’s termite diversity is broader than the historically emphasized two-species view. Understanding the life behavior of *A.ahngerianus* is essential because this species’ survival strategy how it organizes caste labor, selects nesting sites, regulates nest microclimate, shifts foraging routes and depth with temperature and moisture, and exploits cellulose resources in natural and

ISSN 3030-3907

human-modified habitats directly determines when, where, and how damage occurs and therefore how control measures should be designed and timed; in Uzbekistan, termites are treated as a priority pest not only due to economic losses but also because national regulations address termite damage to housing and infrastructure, including the Cabinet of Ministers Resolution No. 27 (2 February 2012) on intensifying termite control and eliminating damage, Presidential Resolution No. PQ-1940 (20 March 2013) linked to protecting tourism assets (e.g., Khorezm), and the 2024 Cabinet of Ministers Resolutions No. 734 and No. 735 (4 November 2024) that regulate identification of termite-damaged residences and strengthen the effectiveness of termite control activities therefore a mechanistic, season-aware understanding of *A. ahngerianus* behavior becomes the scientific foundation for targeted prevention, safer building protection, and evidence-based national management.

TAXONOMY AND DIAGNOSTIC BIOLOGY OF *A. AHNGERIANUS*

Anacanthotermes ahngerianus (Jacobson, early 1900s) is a Central Asian "lower termite" belonging to the genus *Anacanthotermes* (traditionally placed among the desert-adapted termites of the region) and is one of the two *Anacanthotermes* species most frequently emphasized in Uzbekistan and adjacent arid landscapes, alongside *A. turkestanicus*. In practical terms, this taxonomic placement matters for your review because it immediately implies a subterranean, soil–plant–wood interface lifestyle**:** colonies are built belowground, and the species' persistence depends on engineering stable galleries and humid microspaces in otherwise dry environments exactly the ecological "survival engineering" theme you are developing. *A. ahngerianus* as a close congener of *A. turkestanicus* and explicitly studies both species in parallel for functional morphology of key feeding, working structures. From a diagnostic biology standpoint, *A. ahngerianus* should be described using (i) caste-based morphology (workers vs soldiers vs alates) and (ii) field diagnostics tied to nesting and gallery construction. In Central Asian deserts (*Karakum, Kyzylkum, Golodnaya Steppe*), *A. ahngerianus* and *A. turkestanicus* both make subterranean nests, but their colony signs differ: *A. ahngerianus* settlements can be recognized by a slightly raised rounded mound with soil color somewhat different from the surrounding background, whereas *A. turkestanicus* is often detected by earthen galleries built along stems and trunks of dry desert shrubs. The worker and soldier mandibles of *A. ahngerianus* and *A. turkestanicus* were examined comparatively, implying that fine morphological separation may require careful caste sampling and standardized morpho-functional comparison, rather than relying on a single character in isolation.

ISSN 3030-3907

GEOGRAPHIC DISTRIBUTION AND HABITAT ENVELOPE

A.ahngerianus is a characteristic termite of Central Asian arid zones and is reported as widespread in the Karakum and Kyzylkum deserts and the Golodnaya Steppe, where it forms subterranean nests and can often be detected in the field by a slightly raised, rounded mound whose soil color differs from the surrounding background. Although it is largely subterranean under natural desert–semi-desert conditions, the species (together with *A. turkestanicus*) readily occupies anthropogenic habitats, and in cities and settlements it becomes a serious structural pest, damaging wooden materials and wooden building elements (e.g., floors, ceilings), which effectively expands its habitat envelope into human-built and managed landscapes (including irrigated/settlement zones where construction timber and moisture sources are available).

NEST ARCHITECTURE AND CONSTRUCTION MATERIALS

A.ahngerianus typically constructs a predominantly subterranean nest system that is expressed at the surface as low earthen mounds, turrets, or irregular "heaped" structures, depending on soil type, moisture regime, and disturbance; the functional core is an underground network of chambers and galleries that buffers temperature and humidity and connects the nest to food resources through covered runways and foraging tunnels. Nest walls and internal partitions are built from locally collected mineral particles (sand, silt, and clay fractions) that are cemented into stable pellets and layers using saliva and fecal material, forming a compact "soil–organic" composite with enhanced cohesion and reduced permeability. This cementation produces hardened crusts or laminated shells in external portions, while inner zones can be more friable and porous, reflecting a gradient between mechanical strength and ventilation, microclimate control (inner galleries and chambers). Organic inclusions, fine plant fragments, decayed wood particles, and humified material may be incorporated incidentally during pellet formation and repair, but mineral soil remains the dominant construction substrate. Construction is continuous and adaptive: workers extend and repair galleries, thicken exposed surfaces during dry or hot periods, and reinforce conduits and chamber margins where traffic and mechanical stress are highest, allowing the colony to maintain a stable, protected nesting microhabitat in arid and semi-arid landscapes.

MICROCLIMATE CONTROL

Microclimate control is a key factor underlying the survival and ecological success of *Anacanthotermes ahngerianus*, particularly in the arid and semi-arid environments of Central Asia. This species inhabits regions characterized by strong daily temperature fluctuations, low atmospheric humidity, and prolonged dry periods. Under such conditions, maintaining a stable internal nest environment is

ISSN 3030-3907

essential for colony functioning, brood development, and the activity of symbiotic microorganisms. *A.ahngerianus* constructs predominantly subterranean nests and extensive gallery systems within the soil. These underground structures provide effective insulation against extreme external temperatures. The depth of galleries allows the termites to exploit more stable thermal layers of the soil, where temperature and humidity fluctuate far less than at the surface. This structural strategy plays a primary role in passive microclimate regulation. Observations from field studies indicate that termite activity is closely associated with warm and humid microhabitats. In anthropogenic environments, termites often concentrate around heating pipes and moist structural elements of buildings, which create locally favorable microclimatic conditions This behavior reflects the species' strong preference for environments with elevated temperature and moisture, even when the surrounding conditions are otherwise unsuitable. Humidity regulation is particularly critical for *A. ahngerianus* due to its soft cuticle and susceptibility to desiccation. The termites maintain nest humidity through several complementary mechanisms. Soil-based nest walls retain moisture efficiently, while the construction of mud tubes and plastered surfaces reduces airflow and water loss. Freshly built mud coverings are often moist, indicating ongoing maintenance aimed at preserving favorable internal humidity levels. Behaviorally, termites limit exposure to dry external air by remaining within covered galleries and conducting foraging activities primarily within protected pathways. Seasonal and daily activity patterns are also adjusted to avoid periods of extreme heat and low humidity.

SEASONAL ECOLOGY

The seasonal ecology of *A.ahngerianus* reflects its adaptation to the sharply continental climate of Central Asia, where strong seasonal fluctuations in temperature and moisture directly influence termite activity, reproduction, and population dynamics (Toshtemirova, 2024). *A.ahngerianus* exhibits pronounced seasonal variation in activity. The highest levels of foraging and nest maintenance occur during spring and autumn, when moderate temperatures and increased soil moisture create favorable conditions. In contrast, external and near-surface activity declines sharply during the hot summer months (June–August), corresponding to periods of extreme heat and low humidity (Xusanov & Toshtemirova, 2024). During winter, colony activity is largely confined to deeper soil layers, where thermal conditions are more stable. This seasonal vertical migration within the soil profile allows colonies to survive adverse climatic conditions and maintain basic metabolic and social functions year-round. Reproductive cycles in *A. ahngerianus* are strongly synchronized with seasonal environmental cues. The formation and dispersal of winged reproductives (alates) occur mainly in early spring, particularly

ISSN 3030-3907

from April to May. This timing coincides with optimal soil moisture and temperature conditions that favor mating success and colony establishment (Marechek, 1955, 1962, Xusanov & Toshtemirova, 2024). Alates may occasionally be observed outside the peak reproductive season, but mass swarming events are absent during the summer months, indicating strong ecological constraints imposed by heat stress and desiccation. Seasonal factors also influence nest structure visibility and colony density. In protected natural habitats such as the Boday-To‘qay reserve, *A. ahngerianus* constructs surface mounds reaching up to 70 cm in height and approximately 2 m in diameter, with densities ranging from 23 to 30 mounds per hectare (Toshtemirova, 2024). Mound integrity and detectability are highest following spring precipitation, while erosion and reduced maintenance are more common during dry periods. Long-term ecological monitoring has identified *A. ahngerianus* as one of the dominant termite species in several Uzbek ecosystems, where seasonal population dynamics play an important role in trophic interactions and ecosystem functioning (Bienko et al., 2024). The well-defined seasonal patterns observed in *A.ahngerianus* demonstrate its high degree of ecological specialization. Seasonal adjustments in activity, reproduction, and spatial behavior enable the species to persist under extreme climatic conditions and contribute significantly to soil processes, nutrient cycling, and ecosystem stability in arid and semi-arid regions.

FORAGING NETWORK AND RESOURCE ACQUISITION

A. ahngerianus is a subterranean termite species that relies on an extensive system of underground galleries to locate, exploit, and transport food resources. These foraging networks consist of branching tunnels connecting the central nest with feeding sites, allowing workers to move safely between food sources and the colony while avoiding exposure to extreme surface temperatures and predators. Such tunnel systems are especially well developed in arid and semi-arid environments, where surface foraging would result in rapid desiccation (Abdirasulieva & Bekbergenova, 2019). The construction and maintenance of foraging tunnels are carried out primarily by worker termites. Tunnel orientation and expansion are flexible and respond dynamically to resource availability, soil moisture, and seasonal conditions. In compact or saline soils typical of Central Asian deserts, galleries are often deeper and more stable, providing a buffered microenvironment for foraging activity (Zhuginisov et al., 2022). Food discovery in *A. ahngerianus* is mediated by chemical communication. Workers deposit pheromone trails while exploring the substrate, which guide nestmates to newly discovered food sources(Surbhi A et al., 2023; Ulugbek Togaev et al., 2023). Once a suitable resource is found, recruitment intensity increases, resulting in the rapid

ISSN 3030-3907

mobilization of additional workers to exploit the resource efficiently (Ganieva et al., 2023). Experimental studies on *Anacanthotermes* species have demonstrated that plant-derived attractants and moisture-retaining materials significantly enhance foraging activity and feeding intensity. These findings indicate that olfactory cues and humidity gradients play a key role in resource detection and sustained exploitation (Ganieva et al., 2023). *A.ahngerianus* primarily feeds on cellulose-rich materials, including dead wood, plant debris, dry grasses, and processed wood used in human structures. In natural ecosystems, the species contributes to the decomposition of plant litter and woody residues, thereby participating in nutrient cycling and soil formation processes (Abdirasulieva & Bekbergenova, 2019). In anthropogenic environments, *A. ahngerianus* readily exploits wooden construction materials, cardboard, and other cellulose-containing products. This behavioral plasticity explains its economic importance as a structural pest in Uzbekistan and neighboring regions.

SYMBIOSIS AND DIGESTION AS SURVIVAL TOOLS

The ecological success of *A.ahngerianus* in arid and semi-arid environments is fundamentally linked to its symbiotic associations with microorganisms inhabiting the hindgut. Like other lower termites, *A. ahngerianus* lacks endogenous enzymes capable of efficiently degrading cellulose and hemicellulose. Instead, digestion is achieved through a complex and highly specialized symbiotic system involving flagellate protozoa and diverse bacterial communities (Brune & Ohkuma, 2011). This obligate symbiosis enables *A. ahngerianus* to utilize lignocellulosic materials such as dead wood, plant residues, and dry grasses that are abundant but nutritionally poor in desert ecosystems. The ability to exploit these resources provides a decisive survival advantage in environments characterized by low nitrogen availability and limited food diversity. The hindgut of *A. ahngerianus* functions as an anaerobic bioreactor in which symbiotic microorganisms ferment ingested cellulose. Flagellate protozoa initiate cellulose breakdown by mechanically fragmenting wood particles and enzymatically hydrolyzing polysaccharides into simple sugars (Ohkuma, 2003). These sugars are subsequently fermented into short-chain fatty acids primarily acetate which serve as the principal energy source for the termite host. Bacterial symbionts play complementary roles, including hydrogen consumption, acetogenesis, and nitrogen fixation. Nitrogen-fixing bacteria convert atmospheric nitrogen into biologically available forms, compensating for the nitrogen-poor diet typical of cellulose-based feeding (Brune, 2014). This integrated microbial metabolism allows *A. ahngerianus* to maintain colony growth and reproductive capacity under nutrient-limited conditions. The maintenance of gut symbionts in *A. ahngerianus* colonies depends on social

ISSN 3030-3907

behaviors such as proctodeal trophallaxis, through which workers exchange hindgut contents. This behavior ensures the vertical and horizontal transmission of essential symbionts among colony members, particularly during molting, when termites temporarily lose their gut microbiota (Nalepa, 2015). Such socially mediated symbiont transfer reinforces colony cohesion and ensures the long-term stability of digestive functions. The loss of gut symbionts has been shown to result in starvation and death even in the presence of abundant food, highlighting the absolute dependence of termites on their microbial partners. The symbiotic digestive system of *A.ahngerianus* represents a key evolutionary innovation that underpins its ecological role as a decomposer and soil engineer. By converting refractory plant biomass into bioavailable nutrients, the species contributes to carbon cycling and soil fertility in desert and semi-desert ecosystems. From an applied perspective, understanding termite symbiosis and digestion provides valuable insights for termite management strategies. Disruption of gut symbionts has been proposed as a potential avenue for environmentally friendly termite control, emphasizing the practical relevance of this biological system (Ohkuma & Brune, 2011).

INTERACTIONS AND PRESSURES

A.ahngerianus participates in a complex network of interactions with other organisms within its ecosystem. As a detritivorous termite, it competes with other decomposers, including ants, beetles, and microbial communities, for cellulose-rich resources. Spatial segregation, temporal activity patterns, and subterranean foraging networks reduce direct competition and allow coexistence with other soil-dwelling organisms (Brune & Ohkuma, 2011). In some regions, *A. ahngerianus* co-occurs with closely related species such as *Anacanthotermes turkestanicus*. Competitive interactions between these species are mediated primarily through differences in nesting depth, seasonal activity, and foraging intensity, with *A. ahngerianus* generally exhibiting lower aggressiveness but greater ecological flexibility (Zhuginisov et al., 2022). Predation represents a significant biotic pressure on *A. ahngerianus*. Natural enemies include ants, spiders, beetles, reptiles, birds, and small mammals. Ants are considered the most important predators, capable of invading galleries and attacking foraging workers. To mitigate predation risk, *A. ahngerianus* relies heavily on cryptic behavior, subterranean nesting, and covered foraging tunnels (Nalepa, 2015). Group defense strategies, such as rapid retreat into galleries and the sealing of breached tunnels with soil and fecal material, further reduce losses from predation. These collective behaviors highlight the importance of social organization in mitigating external biological pressures. Beyond digestion-related symbiosis, *A. ahngerianus* maintains indirect interactions

ISSN 3030-3907

with soil microorganisms and plants. By fragmenting organic matter and enriching soil with fecal material, termites promote microbial activity and nutrient availability, which in turn enhances plant growth. This reciprocal interaction positions *A. ahngerianus* as an ecosystem engineer influencing soil structure and fertility (Brune, 2014). Human activity exerts both negative and positive pressures on *A. ahngerianus*. Urbanization and agricultural expansion can destroy natural habitats and disrupt colony structure. At the same time, human-made environments often provide alternative food sources and favorable microclimates, particularly in buildings with wooden elements and moisture accumulation (Ganieva et al., 2023). Chemical control measures, including insecticides and bait systems, pose an additional pressure on termite populations(Togaev U et al., 2024). While these measures are effective locally, they may also impact non-target soil organisms and disrupt ecological processes if applied indiscriminately. The interactions and pressures experienced by *A.ahngerianus* have shaped a suite of adaptive traits, including social cooperation, symbiosis, nest engineering, and behavioral flexibility. These adaptations allow the species to persist under intense biotic and abiotic pressures while maintaining its ecological role as a decomposer and soil engineer. Understanding these interactions is essential for predicting population responses to environmental change and for developing sustainable management strategies that balance pest control with ecosystem conservation.

ECONOMIC IMPACT AND WHY IT IS A PEST

A. ahngerianus is one of the most destructive subterranean termite species in Central Asia, particularly in Uzbekistan and neighboring arid regions. Its pest status arises from its ability to colonize both natural and anthropogenic environments, forming large underground colonies that actively exploit wooden structures, agricultural materials, and infrastructure components (Ruzmetov et al., 2023). Unlike forest-restricted termites, *A. ahngerianus* frequently invades human settlements, where constant access to moisture and cellulose-rich materials supports long-term colony survival (Togaev U et al., 2021b). The cryptic nesting behavior of this species, combined with concealed mud galleries, allows infestations to remain undetected until advanced structural damage has occurred, significantly increasing repair costs and economic losses. One of the primary economic impacts of *A. ahngerianus* is the degradation of wooden components in residential, historical, and agricultural buildings. Field and laboratory studies in the Khorezm and Karakalpakstan regions have shown severe damage to timber used in flooring, roofing, doors, and support beams, particularly wood from *Salix* and *Populus* species (Ruzmetov et al., 2023). Damage rates exceeding 90% have been recorded in humid conditions, where fungal growth accelerates wood softening and

ISSN 3030-3907

termite feeding efficiency. Beyond housing, termites also compromise irrigation canals, earthen dams, and wooden utility structures. Their tunneling activity weakens load-bearing materials and accelerates collapse, posing risks to water management systems critical for agriculture in arid regions (Erjigitova et al., 2024). Globally, termite damage is estimated to cause tens of billions of US dollars in losses annually, with subterranean termites responsible for the majority of these costs (Rust & Su, 2012). While precise regional economic estimates for *A. ahngerianus* are limited, available evidence indicates substantial financial burdens related to building repairs, replacement of wooden materials, and pest control interventions in Uzbekistan and surrounding regions (Erjigitova et al., 2024).

MANAGEMENT IMPLICATIONS FROM BEHAVIORAL ECOLOGY

Effective management of *A.ahngerianus* requires a deep understanding of its behavioral ecology. Traditional control methods often fail because they do not account for the species' social organization, cryptic lifestyle, and adaptive foraging strategies. Behavioral traits such as subterranean nesting, cooperative foraging, trophallaxis, and caste specialization directly influence the success or failure of control measures (Shakirzyanova et al., 2025; Akhmedova et al., 2021). By integrating behavioral ecology into management programs, it becomes possible to design targeted, efficient, and environmentally sustainable control strategies that exploit the natural vulnerabilities of termite colonies (Tilyabayev Z et al., 2020). *A.ahngerianus* constructs extensive underground foraging networks that allow workers to exploit food sources while minimizing exposure to predators and environmental stress. This hidden foraging behavior limits the effectiveness of surface insecticide treatments and visual inspection methods (Rust & Su, 2012). From a management perspective, this behavior strongly favors the use of bait-based control systems**.** Because workers share food through trophallaxis, toxic baits can be distributed throughout the colony, ultimately reaching reproductives and immature castes. Studies conducted in Uzbekistan demonstrate that increasing bait attractiveness—especially through biologically enriched substrates—significantly improves control efficiency (Akhmedova et al., 2021).

One of the major challenges in managing *A. ahngerianus* is its behavioral plasticity(Hamid Haytbayev, 2022). Colonies can alter foraging routes, abandon contaminated food sources, and relocate nesting areas in response to disturbance. This adaptability explains the limited long-term success of repeated surface treatments and emphasizes the need for integrated pest management (IPM) strategies (Tilyabaev Z et al., 2017; Ulugbek Togayev et al., 2021a; Erjigitova et al., 2024). IPM approaches combine behavioral knowledge with monitoring, baiting, environmental management, and selective chemical use, ensuring

ISSN 3030-3907

sustainable and cost-effective termite control (З. Тилябаевет al., 2020). Behavioral studies indicate that *A. ahngerianus* responds strongly to chemical cues associated with food quality and microbial activity. Research has shown that termites preferentially feed on plant material colonized by specific fungi, which enhance palatability and nutritional value (Togaev U et al., 2024).

This behavioral preference has direct management implications. Incorporating fungal-treated substrates or semiochemicals into bait formulations increases bait discovery and consumption rates. Such biologically informed approaches improve the efficiency of toxic bait delivery while reducing the amount of active ingredient required.

KNOWLEDGE GAPS AND FUTURE DIRECTIONS

Despite the economic importance of *A.ahngerianus* in Central Asia, species-specific ecological data remain surprisingly limited. Many studies conducted in Uzbekistan and neighboring regions focus on the genus *Anacanthotermes* as a whole, or combine *A. ahngerianus* with *A. turkestanicus*, obscuring interspecific differences in behavior, physiology, and habitat preferences (Zafar & Abdullaev, 2025). As a result, fundamental parameters such as colony lifespan, population dynamics, and dispersal distances of *A. ahngerianus* are still poorly quantified.

Future studies should prioritize long-term field monitoring of identified colonies to establish baseline demographic and life-history data specific to *A. ahngerianus*. Although *A. ahngerianus* is recognized for its adaptability to arid and anthropogenically altered environments, the mechanisms underlying its behavioral plasticity remain insufficiently studied. Existing research documents changes in foraging activity and nesting depth in response to temperature and soil moisture, but experimental data linking environmental stressors to behavioral shifts are scarce (Gulimbetov et al., 2025). Future research should combine controlled laboratory experiments with field observations to clarify how climate variability, irrigation practices, and urbanization influence termite decision-making, colony movement, and resource allocation. Climate change is expected to intensify arid conditions across Central Asia, potentially expanding the suitable habitat for *A. ahngerianus*.

While correlations between desertification and termite outbreaks have been documented, predictive models linking climate scenarios to termite population dynamics are lacking (Zafar & Abdullaev, 2025). Future studies should develop species-specific ecological models incorporating temperature, soil moisture, and land-use change to forecast termite expansion under future climate scenarios. Several studies highlight the expansion of termite populations in Khorezm and Karakalpakstan in response to environmental degradation and Aral Sea desiccation.

ISSN 3030-3907

However, termite monitoring is rarely integrated into broader ecological surveillance programs that track soil condition, vegetation change, and climate trends (Gulimbetov et al., 2025). This separation limits predictive capacity and delays management responses. Future work should integrate termite population monitoring into regional ecological monitoring frameworks, allowing early detection of outbreak conditions and more proactive pest management.

CONCLUSIONS

A. ahngerianus is a highly adapted subterranean termite species whose success in arid and semi-arid regions of Central Asia is driven by a combination of behavioral flexibility, physiological adaptations, and complex social organization. This review demonstrates that the living conditions of *A. ahngerianus* including microclimate regulation, seasonal activity patterns, foraging networks, and symbiotic digestion form an integrated ecological system that enables survival under extreme environmental conditions while simultaneously increasing its pest potential.

The species exhibits pronounced seasonal rhythms, with activity peaks during favorable temperature and moisture periods and vertical migration within soil profiles during climatic extremes. Such seasonal ecology allows colonies to persist year-round despite sharp continental climate fluctuations. Effective microclimate control within nests, achieved through soil architecture and depth regulation, further stabilizes temperature and humidity conditions essential for colony survival. Foraging behavior and resource acquisition in *A. ahngerianus* are characterized by extensive subterranean networks that connect nests to diverse food sources, including desert vegetation, stored plant residues, and wooden structures in anthropogenic environments. This flexible foraging strategy, combined with low selectivity toward cellulose-based substrates, underlies the species' ecological success and its increasing impact on buildings, agricultural infrastructure, and cultural heritage sites. Symbiosis with gut microorganisms is a critical survival tool, enabling efficient cellulose digestion, water conservation, and resistance to pathogenic microorganisms.

These symbiotic systems significantly expand the trophic niche of *A. ahngerianus* and reduce physiological constraints imposed by nutrient-poor desert environments. At the same time, social immunity and antimicrobial defenses further enhance colony resilience. From an applied perspective, *A. ahngerianus* represents a major economic pest in Uzbekistan and neighboring regions, where it causes substantial damage to wooden buildings, irrigation structures, and historical monuments. Traditional chemical control methods remain widely used, but their long-term effectiveness and ecological safety are increasingly questioned. Insights

ISSN 3030-3907

from behavioral ecology—particularly those related to foraging, trophallaxis, and nest organization—offer valuable opportunities for developing more sustainable and targeted management strategies. Overall, this review highlights that *A. ahngerianus* should not be viewed solely as a destructive organism but as a key ecological engineer whose activities influence soil processes, nutrient cycling, and ecosystem structure.

Effective management therefore requires a balanced approach that integrates ecological understanding with pest control objectives. Future termite management programs will benefit from species-specific research, interdisciplinary collaboration, and the incorporation of ecological principles into integrated pest management frameworks.

REFERENCES

1. Abdullaev, I. I. (2016). The population ecology of termites and their role in natural and urban ecosystems (Abstract of doctoral dissertation). Urgench State University, Tashkent, Uzbekistan.
2. Akhmedova, Z., Kholmatov, B., Lebedeva, N., Rustamov, K., Yakhyoev, J., & Kimsanbayev, K. (2021). Importance of fungus in feeding termites with sunflower plants. E3S Web of Conferences, 244, 02042. https://doi.org/10.1051/e3sconf/202124402042
3. Abdirasulieva, Sh. G., & Bekbergenova, Z. O. (2019). Morphological and bioecological characteristics of termites (Isoptera). Uzbek Biological Journal, 3, 45–52.
4. Brune, A. (2014). Symbiotic digestion of lignocellulose in termite guts. Nature Reviews Microbiology, 12(3), 168–180. https://doi.org/10.1038/nrmicro3182
5. Brune, A., & Ohkuma, M. (2011). Role of the termite gut microbiota in symbiotic digestion. In Biology of termites: A modern synthesis (pp. 439–475). Springer.
6. Bienko., et al. (2024). Seasonal monitoring of orthopteroid and termite pests on the Ustyurt Plateau. Young Scientist Research Journal of Karakalpakstan, 1(2), 164–173.
7. Erjigitova, K. K., Zhuginisov, T. I., & Duysengaliev, E. S. (2024). Biological basis for integrated control of termites of the genus Anacanthotermes. Central Asian Journal of Academic Research, 2(6), 72–78. https://doi.org/10.5281/zenodo.12625362
8. Ganieva, Z., Khashimova, M., Rustamov, K., & Akhmedov, V. (2023). The use of attractants in the application of food-baits against termites. Acta Biologica Sibirica, 9, 747–754. https://doi.org/10.5281/zenodo.10121028

ISSN 3030-3907

9. Gulimbetov, B. D., Jiyenbaeva, M. B., Dauilbaeva, K. K., & Medetov, M. J. (2025). Ecological monitoring of winged insects (Insecta: Pterygota) of the Southern Aralkum. Universum: Chemistry and Biology, 1(127), 6–12.
10. Hamid Haytbayev, Ulugbek Togayev, Zoitjon Tilyabayev, Alisher Haytbayev. (2022) Development of effective means protection against termites. Universum Chemistry & biology 91(1) January
11. Marechek, G. I. (1955). Distribution of termites in inhabited areas of Uzbekistan. Marechek, G. I. (1962). Ecological studies of termites in Central Asia.
12. Nalepa, C. A. (2015). Origin of termite eusociality: Trophallaxis integrates the social, nutritional, and microbial environments. Ecological Entomology, 40(4), 323–335. https://doi.org/10.1111/een.12197
13. Ohkuma, M. (2003). Termite symbiotic systems: Efficient biorecycling of lignocellulose. Applied Microbiology and Biotechnology, 61, 1–9. https://doi.org/10.1007/s00253-002-1189-z
14. Ohkuma, M., & Brune, A. (2011). Diversity, structure, and evolution of the termite gut microbial community. In Biology of termites: A modern synthesis (pp. 413–438). Springer.
15. Ruzmetov, R., Abdullaev, I., Bekchanov, M., Atajanova, S., Matyakubov, Z., Doschanova, M., Doschanov, J., Ibragimov, S., & Iskandarov, A. (2023). Tendencies of termites of the genus Anacanthotermes Jacobson to damage the wooden parts of buildings. WSEAS Transactions on Environment and Development, 19, 978–985. https://doi.org/10.37394/232015.2023.19.92
16. Rust, M. K., & Su, N. Y. (2012). Managing social insects of urban importance. Annual Review of Entomology, 57, 355–375. https://doi.org/10.1146/annurev-ento-120710-100634
17. Surbhi A. Tilyabaev Z. Vartika M. Turageldiev S.J. Maxammadshokirov R.Z. Togaev U.R. Chemo-biological aspects of pheromones in ant and termites // Universum: химия и биология : электрон. научн. журн. 2023. 12(114). URL: https://7universum.com/ru/nature/archive/item/16399
18. Shakirzyanova, G., Izotova, L., Eshimbetov, A., Kholbekov, O., Babaev, B., Togaev, U., Ibragimov, B. (2025). Synthesis and Structural Investigation of New Derivate of 5-Mercapto-3-Phenyl-1,3,4-Thiadiazol-2-Thione. New Materials, Compounds and Applications, 9(3), 585-600. https://doi.org/10.62476/nmca.93585.
19. Toshtemirova, N. (2024). Termites (Insecta: Isoptera) of Uzbekistan: Diversity, ecology, and economic importance. In Zamonaviy biologiyaning dolzarb muammolari va rivojlanish istiqbollari (pp. 764–767). Andijan State University. https://doi.org/10.5281/zenodo.15612616

ISSN 3030-3907

20. Togaev U, Turaev A. S, Mathur V, Tilyabaev Z, Zhaloliddinov F, Turageldiyev S, Shakirzyanova G, Khashimova M, Rustamov K, Matchanov A. (2024) Innovative Strategies for Termite Management: Development and Evaluation of Effective Baits against Anacanthotermes turkestanicus. Biotech Res Asia;21(4).
21. Tilyabaev Z, Babaev BN, Khaytbaev H, Togaev UR. (2017) Application of the chemicals against termites. Scientific Discussions. 1(7):6-13.
22. Togaev U., Khaitbaev K., Tilyabaev Z., Toshov K., Khaitbaev A.(2021b) Investigation of the attractive properties of compounds in Anacanthotermes turkestanicus. Nat. Volatiles & Essent. Oils; 8(7): 12564–12573.
23. Togaev U., Rakhmonkulova A., Sharma M., Agarwal S., Turaev A.S., Tillyabaev Z., Matchanov A., Khodja-Akhmedova K., Ruzmetov R., Abdullaev I., Mathur V. Whole Metagenomic Analysis of the Gut Microbiome of Higher Termites (Microcerotermes turkmenicus Luppova, 1976) in Uzbekistan. Acta Microbiol. Bulg. Volume 41, Issue 3, 2025 / Pages 341-346 / https://doi.org/10.59393/amb25410308
24. Tilyabayev Z., Haytbaev H., Togaev U.R. Main stages of development and use of plant protection products against harmful insects // International science project. - 2020. - № 3. - C. 22-28.
25. Ulugbek Togaev, Vartika Mathur, Shuhrat Turageldiev. (2023) Analysis of Cuticular Hydrocarbons in Anacanthotermes Turkestanicus: A Scientific Inquiry into Insect Cuticular Lipids. Conference: The International Conference on Energy-Earth-Environment-Engineering. Tashkent. 5.12.2023
26. Ulugbek Togayev, Zoitjon Tilyabayev, Hamid Haytbayev. (2021a) Investigation of the thermiticidal properties of naphthalene derivatives. № 3 (81)
27. Xusanov, A. K., & Toshtemirova, N. I. qizi. (2024). Research on termites (Insecta: Isoptera) in Uzbekistan. Andijan State University Proceedings.
28. З. Тилябаев, Х. Хаитбаев, Б.Н. Бабаев, У.Р. Тогаев (2020) Термитициды / Universum: химия и биология: электрон научный журнал. – № 5. – С. 42–46
29. Zafar, M. S., & Abdullaev, I. I. (2025). Biology and ecology of termites in Khorezm and Karakalpakstan, Uzbekistan. Proceedings of the International Conference on Health & Technology, 22–25. https://doi.org/10.5281/zenodo.17588209
30. Zhuginisov, T. I., Orazbaeva, S. M., Duysengaliev, E. S., Dawletmuratov, I. Z., & Isaev, R. T. (2022). Monitoring and prevention of termites of the genus Anacanthotermes in the conditions of Karakalpakstan. Science and Education in Karakalpakstan, 1(1), 54–57.

ISSN 3030-3907

31. Zhuginisov, T. I., Juginisov, T. I., Orazbaeva, S. M., Duysengaliev, E. S., Dawletmuratov, I. Z., & Isaev, R. T. (2022). Monitoring and prevention of termites of the genus Anacanthotermes in the conditions of Karakalpakstan. Science and Education in Karakalpakstan, 1(1), 54–57.

ISSN 3030-3907