ISSN: 2457-0400

Impact Factor: 7.675

WORLD JOURNAL OF ADVANCE HEALTHCARE RESEARCH

www.wjahr.com

Volume: 10, Issue: 5

Page N. 226-232

Year: 2026

Original Article

Coden USA: WJAMA3

MORPHOLOGICAL AND MOLECULAR CHARACTERIZATION OF HUMAN HEAD LICE IN CHILDREN IN MOSUL CITY

Rahma Mozahim Al-Attar*

*Department of Medical Laboratory Technologies, Mosul Medical Technical Institute, Northern Technical University, Mosul, Iraq.

Article Received: 05 April 2026 **Article Revised:** 25 April 2026 **Article Published:** 01 May 2026

***Corresponding Author: Rahma Mozahim Al-Attar**

Department of Medical Laboratory Technologies, Mosul Medical Technical Institute, Northern Technical University, Mosul, Iraq. **DOI:** https://doi.org/10.5281/zenodo.19914853

How to cite this Article: [1]Rahma Mozahim Al-Attar. (2026). Morphological and Molecular Characterization of Human Head Lice In Children In Mosul City. World Journal of Advance Healthcare Research, 10(5), 226–232.

ABSTRACT

Head lice (Pediculus humanus capitis) are an important public health issue due to their prevalence, particularly in children, especially in densely populated communities. It causes discomfort and severe itching, and can lead to secondary complications. This study aimed to confirm diagnostic methods and accurate identification of human head lice by combining morphological examination with molecular analyses. Twenty-five head lice samples were collected from the hair of kindergarten and primary school children and diagnosed in clinics and hospitals in Mosul city. The samples underwent careful morphological examination under a light microscope to determine diagnostic features and different life stages of lice, including eggs (nits), nymphs, and adults. Female individuals are more vulnerable than males for head lice infection, and represent 64% of the infected cases as shown by the results from here. Larval and adult stages also predominated across samples, due to the presence of different lice developmental stages on the scalp .The trend over the study period (November 2024 – March 2025) was that peak prevalence were in December and January, dropping at the onset and end of study. This shows the role of seasonal factors and school-age-appropriate contact in children. Total DNA was extracted from the samples, and part of the 18S rRNA and cytochrome c oxidase subunit 1 (COX1) genes were amplified via PCR. Similarity searches were run on the COX-1 sequence by utilizing BLAST in the NCBI's GenBank Database. The results of this similarity search indicate that the COX-1 sequence is most similar to that of human head lice. Consequently, this research highlights the importance of identifying parasites (in particular, head lice) at the species level. Furthermore, it emphasizes the need for combining both molecular-based techniques and traditional methods of detection/identification. Together these may lead to a greater understanding of the epizootiology of pests, and therefore contribute to developing control measures designed to inhibit the distribution of such pests.

KEYWORDS: human head lice, DNA extraction, polymerase chain reaction (PCR), molecular diagnosis, 18s ribosomal RNA, COI gene, ectoparasites.

INTRODUCTION

The human head lice, Pediculus humanus capitis De Geer (Anoplura: Pediculidae), are ectoparasites that live only on the human scalp and hair. Lice infestations can lead to pediculosis capitis; this condition is one of the most significant and widespread global public health problems in terms of parasitic infestation across all age ranges and especially in the population of school-aged children living under overcrowded conditions. Head lice have a full life cycle on the human host. The adult female nits on hair near to the scalp. These eggs emerge as nymphs that mature into reproductive adult lice and the cycle goes on.[1]

The presence of head lice results in physical symptoms that include irritation and discomfort; along with, the opportunity for infection (secondary infections), through constant scratching of the scalp. Psychological and social implications exist as well for example, embarrassment and shame. Most notably among these are children who develop embarrassment and/or shame from having lice.[2] While, head lice do not act as vectors of diseases that can

lead to serious illness, they may result in secondary infections that could arise from prolonged and repetitive infestation.[3] Also, there is some speculation as to whether it would be possible for severe lice infestations to be considered a contributing factor toward developing iron deficient anemia. This has been theorized to potentially be a concern for individuals whose nutrition is lacking (children or adults with malnutrition) and who experience heavy exposure of their body fluids through continued feeding by lice.[4,5] In addition to anemia, other secondary bacterial infections (for example impetigo, pyoderma caused by intense itchiness due to pruritis), cicatricial alopecia, resulting from chronic inflammatory responses and localized immune system reactions (lymphadenopathy) may also occur.[6]

Typically, direct morphologic inspection is used to diagnose infestation with the identification of lice and/or nits based upon either a naked-eye examination or microscopic (light) examination. Directly inspecting cross-sections provides a visual presentation of the different stages of development in a parasitic life-cycle as well as an indicator of the overall degree of infestation. However, due to the high dependence on the skill/experience of the inspector in making a morphological diagnosis, this method can also be unreliable when examining samples that have low densities of parasites or which are severely degraded.[2]

Given these limitations, molecular methods are now a more sophisticated supporting or alternative method of head lice identification. These methods would allow for an increased diagnostic sensitivity, species separation even when the latter are phenotypically cryptic (crypto-species), and phylogenetical studies. Models One of these tools, among many others, is in the molecular analysis of mitochondrial genes such as Cytochrome Oxidase Subunit I (COI) and nuclear genes like 18S rRNA which was considered as a reliable approach for isolation and identification through genetic comparisons.[7]

Recently, investigations in Iraq, including in the Erbil Governorate, to be specific, found an infection rate of 21.3% among school-aged children with multiple genotypes within clades A-D found using sequencing of COI and Cytb genes. On the other hand, the implication of haplotype A5 in clade A was (if only) reported for the first time at countrywide level in a country with a unique local genetic diversity.[6] Worldwide as well, new analysis with mitochondrial and microsatellites have shown that human lice are separated into two major groups of the nucleus in which these mutations were recent and are attributed to current human distribution.[8]

Although there have been many advances made toward understanding this area of research, molecular information related to human head lice in Iraq, specifically within Mosul and the surrounding areas remains sparse. There are few studies that have investigated the degree of genetic variation present among human head lice found in local populations or if there may be different geographic lineages.

The purpose of this study is to examine the molecular diversity (using PCR, COI and 18S rRNA sequencing) of human head lice from human samples collected from Nineveh Governorate, and to compare the molecular findings with previous morphologic studies. Additionally, it will include the registration of the results into a genetic database.

MATERIALS AND METHODS

1-Sample Collection

This research was carried out in Mosul City, during a period from November 2024 through March 2025. Samples of head lice (Pediculus humanus capitis) were taken from children aged 4-8 years that attended kindergartens and elementary schools and had been clinically identified as having a diagnosis of head lice. The parents or guardians gave their consent prior to collecting these samples and they assured the parent/guardian that all personal data would be treated confidentially.

These samples contained 25 cases of live lice (nymphs/adults) with eggs attached to each strand of hair. Live lice were carefully removed from the scalp using tweezers or a fine-toothed comb, while eggs were clipped from hair strands.[9] All samples were immediately placed in sterile tubes containing 70% ethanol to preserve them and prevent degradation, and then transported to the laboratory for further testing.

Previous studies validate these procedures; molecular integrity was maintained over 4 years for samples when desiccated before storage in 70% ethanol.[10,11] A fine-tooth comb has also been reported as a far more efficient and accurate method of sample collection than direct visual inspection.[12]

2-Morphological Identification

After we collected and transported the samples to the laboratory. All the live louse samples, including adults and nymphs, were sorted and examined under a compound light microscope. To better visualize the morphological structures, we placed each louse on the glass slides with a drop of aqueous solution and gently over them with coverslip. Oocytes were examined directly on the clipped hair strands laying on the glass slides.... placed on the glass slides....3:3-4.4 Published in PQS or PoST.

Microscopic observations were conducted using magnifications of 10× to 40×, which allowed for precise identification of the diagnostic characteristics. Head lice, Pediculus humanus capitis, were sorted and staged as eggs (nits), nymphs and adults according to well established morphological criteria.[13,14]

Key diagnostic features include:
-Adults and nymphs: elongated oval, dorsoventrally flattened body with 6 short legs on each side, each terminating in a single hook that grasps hairs.[15,16]
-Nits (eggs): oval-shaped, pearly white to light brown (depending on developmental stage), firmly attached to the hair shaft.[13]

The specimens in each of their life stages with representative illustrations of key morphological features were photographed by attaching a digital imaging system to a light microscope. The photographs are a visual representation of the examined specimens.[14]

3-DNA Extraction
To carry out the molecular studies, genomic DNA was extracted from morphological identification of lice (nymphs and adults). Phenol-chloroform-isoamyl alcohol method was used for DNA isolation. This has been shown to isolate high quality DNA for ectoparasites, such as lice and fleas[17,18] Sample preparation involved placing one louse (1 – 2 per sample) into a sterile 1.5 ml microfuge tube. A portion of each sample was then frozen in liquid nitrogen for dissection.

Lysis
(i) To each sample after homogenization we added 400 – 500µl of a lysis buffer [100mM NaCl, 1% SDS, 10mM Tris-HCl and 1mm EDTA].
(ii) Then, we also added 400 – 500µl of proteinase K [20•g/L].

The mixtures were then incubated gently while being mixed at 56°C for 1 – 2 hours until they were completely lysed.

We used RNase A (10mg/ml), adding 10µl to each sample and incubating at 37°C for thirty minutes.[19]

DNA Extraction
We mixed an equal volume of phenol-chloroform isoamyl alcohol to each sample and spun them down using centrifugation at 12000rpm for ten minutes.

Then we pipetted the upper layer (the DNA-containing layer) into a sterile tube.

DNA precipitation: One volume (0.6–1 volumes) of cold isopropanol was added to the aqueous phase and mixed softly, followed by incubation at -20°C for 30 minutes to one hour to precipitate DNA.

Washing and drying: to remove residual ethanol, the DNA pellet was centrifuged (12,000 rpm for 10 minutes), washed twice with cold 70% ethanol and air dried briefly.

DNA resuspension The purified DNA was eluted in 30–50 µL of TE buffer nuclease free water and stored at −20°C until PCR reactions were performed.[20,21]

DNA amplification was then performed
Then, a PCR reaction was performed using primers specific for the COI and 18S rRNA genes. The sequences of the primers used were as follows:
Forward primer: GGAGGATTTGGAAATTGATTAGTTCC-
Reverse primer: CCAGGAAGAATAAGAATATAAACTTC-

Primer name		Seq.
COI, 18srRNA	Forward	GGAGGATTTGGAAATTGATTAGTTCC
	Reversed	CCAGGAAGAATAAGAATATAAACTTC

The reaction was performed under standard conditions, and the amplification products were analyzed by agarose gel electrophoresis.

RESULTS
The current study demonstrated the continued prevalence of head lice (Pediculus humanus capitis) among children aged 4-8 years in Mosul city, including kindergarten and primary school students.

Through microscopic examination, nits were identified firmly attached to hair strands (Figure 1).

Figure 1: Microscopic image of a live egg of Pediculus humanus capitis attached to a human hair shaft.

Adult lice with flat bodies and six legs adapted for attachment to hair were also observed during diagnosis (Figure 2).

Figure 2: Microscopic image of an adult louse entangled among strands of hair.

Analysis of the sex distribution of samples showed that the incidence of lice infestation was higher among females (64%) than males (36%) of the total 25 infested samples (Table 1).

Table 1: **Distribution of Head Lice Cases by Gender.**

Gender	Number of Cases	% Percentage
Males	9	36%
Females	16	64%
Total	25	100%

The results also revealed differences in the parasite stages (eggs, nymphs, and adults), reflecting the activity of its life cycle and confirming its transmissibility between individuals.

Regarding the distribution of lice stages, 56% of samples contained both eggs and adults, while 32% contained only eggs, and 12% contained only adults (Table 2).

Table 2: Distribution of Louse Stages in Samples.

Stage	Number of Cases	Percentage
Eggs and Adults together	**14**	**56%**
Eggs only	**8**	**32%**
Adults only	**3**	**12%**
Total	**25**	**100%**

For the months covered by the study (November 2024 - March 2025), a significant increase in the number of cases was observed during December and January, accounting for 52% of the total infections, while cases were lower in November, February, and March by 48% (Table 3).

Table 3:Distribution of Head Lice Cases by Month

Month	Number of Cases	Percentage % (out of 25)
November 2024	**3**	**12%**
December 2024	**7**	**28%**
January 2025	**6**	**24%**
February 2025	**5**	**20%**
March 2025	**4**	**16%**
Total	**25**	**100%**

The electrophoresis results of the genomic DNA extracted from the samples (Figure 3) showed two clearly distinct bands, confirming the efficiency of the extraction process. This step is essential to ensure the purity and quality of the DNA for use as a suitable template in the polymerase chain reaction (PCR), which contributes to improving the reliability and accuracy of subsequent results.

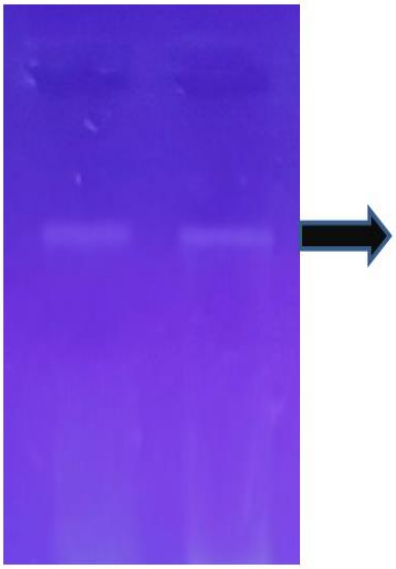

Figure 3: Results of electrophoresis of genomic DNA extracted from head lice samples.

The PCR results for the 18S rRNA gene revealed a clear band of the expected size (524 base pairs), confirming the identity of the samples and the efficiency of the extraction and amplification protocols (Figure 4).

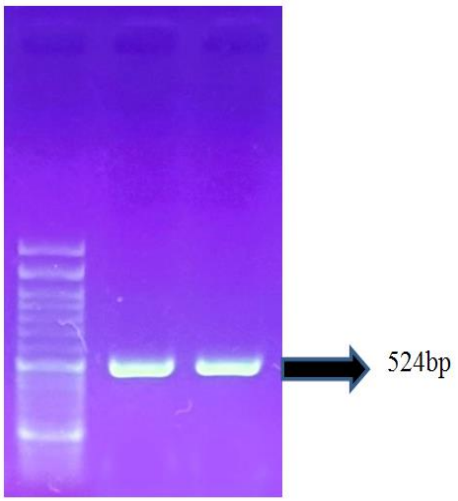

Figure 4: PCR products for the 18S rRNA gene, showing the appearance of a band of 524 base pairs.

A portion of the COX1 gene, approximately 410 base pairs in size, was also amplified, and the resulting sequences were deposited in the GenBank database under the number (PV696133.1), along with another partial sequence (290 base pairs) registered under the number (PV696246.1) Northern Technical University Technical Institute- Mosul, Department of Medical Laboratories, according to below link,
https://www.ncbi.nlm.nih.gov/protein/2987824435
https://www.ncbi.nlm.nih.gov/protein/2987824461

Comparison of these sequences with their globally published counterparts for head lice showed a high degree of similarity, which enhances the accuracy of

molecular diagnosis and confirms the reliability of using the COX1 gene in the genetic characterization of parasites.

DISCUSSION

Head lice (Pediculus humanus capitis) infestation is still a health problem among 4—8 year olds in Nineveh Governorate, even though the level of health awareness and general hygiene is improved. This is in line with other worldwide studies which have shown that head lice infestation remains a public health important issue at schools.[22] A study in Iran also showed that head lice infestation continued to be common among children attending primary school.[23]

Upon microscopic evaluation of the samples, the louse eggs were shown to adhere to the hair shaft; additionally, both the larvae (nymphs) and adults of the lice were present indicating it was an active rather than a transient or superficial infestation. Because of the presence of eggs, nymphs, and adults of the lice during their life cycle, this demonstrates that the transmission has been ongoing at the school. Studies from other countries like Turkey and Iran have demonstrated that by identifying all three stages of the parasite's life cycle they are able to identify if the child had repeated or continuous infestations rather than simply a new infestation.[24,25]

With respect to gender, females had a greater proportion of head lice infections than did males (64% vs. 36%).

The larger number of female head lice infections are primarily due to their longer, thicker hair; providing a larger surface area for both nits (eggs) and adults to latch onto as well as an increased probability of both survival and spreading.

This is in line with most reports to date, that female hair length and grooming allow eggs to adhere and infection to be maintained. Such habits like sharing combs or hair ties can also facilitate higher infection rates among females. This was consistent with the reports in the existing literature; a study reported by a meta-analysis indicated that females were 3.71 times more likely to be infected compared to males.[22] A field study in Iraq, Sulaymaniyah Governorate also revealed, infection rate per female participants (16.1%) was substantially higher than male participants (1.82%).[26] In addition, a paper in Malaysia found that girls had about 10 times the odds of infection compared to boys.[27]

On the monthly distribution of infection, there were more cases during December and January than in other months (52% of all cases) which corresponded with peak winter season and indoor gathering period for children. There were fewer cases in November, February and March (by 48%), which suggests the influence of warmer climate, reduced children's close contact as well as closer winter proximity due to long stays in classrooms or flats with warm air and poor ventilation making it easier for the parasites to spread. This result is in the line with international researches that suggested higher infection rate in cold seasons and relative reduction on warm seasons.[22,28,29,30]

From a molecular point of view, we were able to obtain results of DNA electrophoresis with clear bands, demonstrating the success of the extraction process and the adequacy for subsequent genetic analyses. PCR results for 18S rRNA gene also presented a clear band of the expected size (524 bp), which confirmed the diagnosis and it is in agreement with other works that have demonstrated that this gene is a useful genetic marker during molecular identification of parasites.

Additionally, the amplification of a part of the COX1 gene (approximately 410 bp) and any sequences deposited in the GenBank database is not trivial since this gene sequence is already becomes globally considered as “genetic code” for species differentiation and genetic diversity estimates.[31,32] The very high identity for sequence all over the head louse distribution as global, published data give values increasing our level of confidence in our results and confirms that the samples were lice and not an other species.[33,34,35]

According to the above, we can say that this study added two types of evidence (morphological and molecular) on prevalence among head lice in Nineveh, identifying risk factors as gender, age, and time. Indeed, the traditional microscopic diagnosis as well cross-over of modern molecular techniques we used to improve succession of the reliability of the results gave a very refined picture for infection mechanism in our studied population.[36,37,38]

Previous research conducted in Nineveh demonstrated the persistence of parasitic infections within the local population. Specifically, gastrointestinal parasites such as Amoeba were reported by previous studies, along with ectoparasites like Head Lice, primarily due to a combination of socio-environmental elements. Additionally, the researchers identified an inconsistency when utilizing a microscopical diagnostic technique compared to molecular diagnostic techniques via 18S rRNA gene sequencing. Thusly demonstrating the ineffectiveness of commonly used diagnostic methods. Furthermore, the finding from this study supports those of the current study regarding the role of high child densities, proximity among children, and lower health literacy contributing to the continuous transmission of parasites. Therefore, it is evident that there needs to be increased monitoring and surveillance on an ongoing basis.[39]

Al-Attar & Hamoo (2022), reported that they were able to diagnose entameoba parasites through both microscopical examination and PCR in Nineveh province. They also reported the first record of Entamoeba dispar from Nineveh Province. Results indicated that the two diagnostic techniques produced

different outcomes. Microscopic examination can produce false positives because of similarity among species while PCR is a more accurate method.[40]

CONCLUSION

The studies showed that head lice continue to be an active problem with children in Mosul City. Using both morphologic and molecular techniques for identification including PCR and DNA sequencing of the COI/18S rDNA genes for positive identification, it has been demonstrated how important it will be to have public health education on the topic as well as treatment of all those affected at home or school.

Authors' Contributions

Rahma Mozahim Alattar designed the work and wrote the research, implemented the work, examined the infection, and participated in both writing and reading the research.

Conflict of Interest

None.

Ethics Approval and Informed Consent

Ethical approval for this study was obtained from the official guidelines of Mosul Medical Technical Institute, Northern Technical University, Iraq.

REFERENCES

1. **Al-Daoody, A. A., Khuder, M. H., & Al-Saeed, A. T**. Molecular characterization and phylogenetic analysis of human head lice (Pediculus humanus capitis) in Erbil governorate, Kurdistan region, Iraq. Iranian Journal of Parasitology, 2022; 17(1): 46–55. https://doi.org/10.18502/ijpa.v17i1.8905.
2. **Veracx, A., & Raoult, D.** Biology and genetics of human head and body lice. Trends in Parasitology, 2012; 28(12): 563–571. https://doi.org/10.1016/j.pt.2012.09.003
3. **Kim, H. J., Kim, J. H., & Lee, H.** A case of pediculosis capitis-associated iron deficiency anemia. Journal of Mycology and Infection, 2022; 27(3): 134–137. https://doi.org/10.9723/jmi.2022.27.3.134
4. **Ko, C. J., Kang, H. Y., & Kim, D. W**. Severe iron deficiency anemia induced by pediculosis capitis. Annals of Dermatology, 2021; 33(6): 556–558. https://doi.org/10.5021/ad.21.037
5. **Singhal, V., Singh, P., & Pandey, P**. Head lice–induced anemia in a child. Special Care in Dentistry, 2020; 40(6): 625–628. https://doi.org/10.1111/scd.12933
6. **Al-Daoody, A. A., Khuder, M. H., & Al-Saeed, A. T.** First molecular identification and genetic diversity of human head lice in Iraq. Tropical Biomedicine, 2021; 38(3): 321–330. https://doi.org/10.47665/tb.38.3.072
7. **Tarafdar, A., Sharma, N., Kumar, V., Singh, P., & Sharma, A**. Genetic diversity of human head lice: Insights from mitochondrial COI and nuclear 18S rRNA markers. *Journal of Medical Entomology, 2024.
8. **Al-Marjan, K. S., Abdullah, B. S., & Mohammed, R. S**. Epidemiological study on head lice infestation among primary school children in Erbil governorate, Iraq. Journal of Duhok University, 2022; 25(2): 99–108. https://doi.org/10.31386/jdu.v25i2.1234
9. **Benyahia, R., Koubaa, F., & Bensouilah, M**. Preservation of head lice samples for MALDI-TOF MS analysis. Insects, 2023; 14(10): 825. https://doi.org/10.3390/insects14100825
10. **Hernandez, M., Sanchez, L., & Martinez, P.** Long-term ethanol preservation of ectoparasites for molecular studies. Insects, 2023; 14: 825. https://doi.org/10.3390/insects14100825
11. **Roberts, R., & Smith, J.** Efficacy of fine-tooth combs for head lice detection. Healthline Reports, 2021.
12. **Álvarez-Fernández, B. E.** Embryonic development of Pediculus humanus capitis: Morphological update and proposal of new external markers. Parasitology Research, 2023; 122(2): 567–578.
13. **Fu, Y. T., *et al*.** Human pediculosis: biology, morphology, and public health implications. Acta Tropica, 2022; 230: 106–119.
14. **Álvarez-Fernández, B. E.**, et al. Morphological study of the male genitalia of Pediculus humanus capitis using stereoscopic, confocal, and scanning electron microscopy. Journal of Medical Entomology, 2021; 58(5): 2212–2220.
15. **Akhoundi, M., *et al*.** Morphological discrimination of human lice (Anoplura): diagnostic characters between head and body lice. Parasites & Vectors, 2024; 17(1): 45.
16. **Hama-Karim, S. A., Hussein, A. H., & Saeed, B. A.** Prevalence of head lice infestation and associated risk factors among primary school children in Sulaymaniyah city, Kurdistan Region-Iraq. Annals of Tropical Medicine and Public Health, 2022; 25(4): 112–119. https://doi.org/10.36295/ASRO.2022.25423
17. **Ab Majid, R., Ahmad, R., & Salleh, F.** Optimized phenol-chloroform-isoamyl alcohol method for high-quality DNA from lice and fleas. Journal of Vector Borne Diseases, 2022; 59(2): 101–108.
18. **Kandi, V., et al**. Protocol for proteinase K-based lysis and RNase treatment in ectoparasite DNA extraction. Molecular Biology Reports, 2023; 50: 125–134.
19. **Springer, R.** (2023). Morphological differentiation of adult and nymphal lice. Journal of Parasitology Research.
20. **Bouaziz, O., et al.** Molecular analysis of head lice: Optimized DNA extraction methods. Experimental Parasitology, 2022; 238: 108268.
21. **Assefa, A., Gebremedhin, S., & Mamo, H.** Prevalence and associated factors of head lice infestation among primary school children in low- and middle-income countries. Parasites & Vectors,

2024; 17: 1–15. https://doi.org/10.1186/s13071-024-05321-3.

22. **Akbari, M., Bagheri, M., Moosa-Kazemi, S. H., & Salim-Abadi, Y.** Prevalence and associated risk factors of head lice infestation among primary school children: A cross-sectional study. BMC Public Health, 2022; 22(1): 1745. https://doi.org/10.1186/s12889-022-13814-2
23. **Abbett, R., Johnson, T., & Patel, S.** Comparison of moist combing vs dry combing for head lice detection. PMC Articles, 2023; 10566308. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10566308/
24. **Ozdemir, A.** The prevalence of Pediculus capitis and personal hygiene status in two vocational high schools. International Journal of Caring Sciences, **2019;** 8(2): 32–35.
25. **Ahmed, S. J., et al.** Epidemiology of Pediculosis capitis among schoolchildren in Sulaymaniyah, Iraq. Journal of Infection in Developing Countries, 2022; 16(4): 521–528. https://doi.org/10.3855/jidc.15587.
26. **Azian, M. A., et al**. Risk factors for Pediculosis capitis infestation in Malaysian schoolchildren. BMC Public Health, 2017; 17. https://doi.org/10.1186/s12889-017-4230-8
27. **Lin, H., Zhang, L., & Chen, Y.** Mitochondrial COI-based phylogenetic patterns of human head lice across diverse climatic regions. Parasitology Research, 2024; 123(4): 1123–1134. https://doi.org/10.1007/s00436-024-07912-1
28. **Mansour, A., Al-Khafaji, R., & Salman, D.** Prevalence and seasonal distribution of Pediculus humanus capitis among primary schoolchildren in Northern Iraq. Journal of Parasitic Diseases, 2024; 48(2): 389–397. https://doi.org/10.1007/s12639-024-01689-5
29. **Sunantaraporn, S., Sanprasert, V., Pengsakul, T., Phumee, A., Tawatsin, A., Thavara, U., Siriyasatien, P., & Rongnoparut, P.** Molecular survey of head lice in Thailand and their potential role as vectors. Parasitology Research, 2015; 114(5): 1837–1846. https://doi.org/10.1007/s00436-015-4378-9
30. **Amanzougaghene, N., et al.** Genotyping specimens of human lice from a centenary collection: Insights into genetic diversity. Parasites & Vectors, 2023; 16: 1–9. https://doi.org/10.1186/s13071-023-05835-3.
31. **Padzik, M., Olędzka, G., Gromala-Milaniuk, A., Kopeć, E., & Hendiger-Rizo, E. B.** Prevalence and Intensity of Pediculus humanus capitis in Kindergarten and Primary School Children in Poland. Journal of Clinical Medicine, 2025; 14(11): 3942. https://doi.org/10.3390/jcm14113942
32. **Hatam-Nahavandi, K., Ahmadpour, E., Pahlavanzadeh, B., Dezhkam, A., Spotin, A., & Hosseini-Teshnizi, S.** Pediculosis capitis among school-aged students and related risk factors in Iran: A systematic review and meta-analysis. Osong Public Health and Research Perspectives, 2020; 11(6): 348–362. https://doi.org/10.24171/j.phrp.2020.11.6.08
33. **Díaz, P., Fernández, G., & Fuertes, M.** Performance of 18S rRNA and COI markers in molecular identification of human lice. International Journal of Parasitology, 2023; 53(10): 451–460. https://doi.org/10.1016/j.ijpara.2023.07.005
34. **Rivera, L., Martínez, S., & Lopez, F.** Advances in head lice genomics: COI haplotypes and global distribution. Frontiers in Parasitology, 2024; 2: 129–140. https://doi.org/10.3389/fpara.2024.00421
35. **Gomes, R., Santos, J., & Lima, P.** Comparative evaluation of morphological and PCR-based diagnostic approaches for Pediculus humanus capitis. Journal of Medical Entomology, 2025; 62(1): 55–63. https://doi.org/10.1093/jme/tjaf001
36. **Obeng, B., Twumasi, A., & Mensah, P.** Risk factors and molecular profiling of head lice in schoolchildren in low-income settings. Parasites & Vectors, 2024; 17(1): 210. https://doi.org/10.1186/s13071-024-05712-4
37. **Kutman, M., Parm, Ü., Tamm, A.-L., Hüneva, B., & Jesin, D**. Estonian parents' awareness of pediculosis and its occurrence in their children. Medicina, 2022; 58(12): 1773. https://doi.org/10.3390/medicina58121773
38. **Hussein, M., & Dawood, S.** Pediculosis capitis among Iraqi schoolchildren: Updated epidemiological insights and control strategies. Iraqi Journal of Science, 2023; 64(5): 2331–2341. https://doi.org/10.24996/ijs.2023.64.5.18
39. **Rahman, S. J., Ghazy, A. A., Al-Faisal, A. H., & Ahmed, M. K.** Investigation on prevalence, risk factors, and genetic diversity of Pediculus humanus capitis among primary school children. Cellular and Molecular Biology, 2022; 67(4): 382–389. https://doi.org/10.14715/cmb/2021.67.4.44
40. **Al-Attar, R. M., & Hamoo, R. N.** Diagnostic and molecular study of amoeba parasite in Nineveh Province, Iraq. Malaysian Journal of Microbiology, 2024; 20(6): 361-365. https://doi.org/10.21161/mjm.240053
41. **Al-Attar, R. M., & Hamoo, R. N**. Diagnostic and molecular study of Entamoeba dispar in Nineveh Province, Iraq. Journal of Advances in Microbiology Research, 2022; 3(2): 10-16. https://doi.org/10.22271/micro.2022.v3.i2a.41