Plasmodium – an overview over the lifecycle

Plasmodium is a parasitic unicellular eukaryote belonging to the primarily parasitic Phylum Apicomplexa which is part of the Alveolates, many of which have a flattened membranous sack, the alveoli, as a common characteristic. Genus belonging to Apicomplexa often have an apical complex, used to enter their host. The alveolates can be found in the supergroup SAR, together with Stremenopiles and Rhizaria. Species belonging to the family plasmodium have been known to effect vertebrates, from humans, other apes, to birds and reptiles.


Picture 1

The study of *Plasmodium* is of significant interest due to 5 species been known to cause Malaria in humans. For the year 2021 about 247 million cases of Malaria were reported worldwide with 619000 estimated deaths.[1] Symptoms are headaches, high fevers, diarrhoea, anaemia, renal disfunction and pulmonary disfunction. Metabolites of haemoglobin seem to be responsible for the high fevers. While general diagnosis of *Plasmodium* is possible under a microscope, molecular diagnosis like DNA sequencing is necessary to distinguish the species.[2] Beside the clinical relevance it has to be stated, that Malaria is furthermore also a socioeconomic problem with more less developed countries being affected.

All *Plasmodium* species that are clinically most relevant are transmitted by the anopheline mosquito and undergo a similar lifecycle.[3] *Plasmodium* is transmitted as sporozoite by the mosquito and starts immediately after the bite to migrate to and infect hepatocytes.[4,5] This stage does often not show any acute symptoms. There they multiply and mature before being released as active, erythrocyte infecting parasites called merozoite.[6] In the erythrocytes, *Plasmodium* undergoes multiple mitosis cycles leading to an even higher parasitic load for the host.[7] Sexual reproduction only takes place back in the gut of the mosquito after it taking up gametes from a host.[8] Exposure to the midgut lumen triggers the differentiation into a macro and microgamete which fuse into a zygote.[8] Meiosis of the zygote leads to the ookinete which will penetrate the wall of the gut and become an oocyst.[9] In the oocyst plasmodium undergoes sporogony, the formation of the infectious sporozoites.[10] When the oocyst ruptures, the sporozoites will migrate to the salivary gland from where they then be again transmitted by the mosquito biting a host.[11]

Further interesting for research is the factor plasmodium played in human evolution with genetic adaptations like Sichel cell disease or Thalassemia that seem protective against a malaria infection but carry their very own complications.[12]

References:

1) WHO World malaria report 2022
2) Singh, B., Kim Sung, L., Matusop, A., Radhakrishnan, A., Shamsul, S. S., Cox-Singh, J., Thomas, A., & Conway, D. J. (2004). A large focus of naturally acquired Plasmodium knowlesi infections in human beings. *Lancet (London, England)*, *363*(9414), 1017–1024. https://doi.org/10.1016/S0140-6736(04)15836-4
3) *Votýpka J, Modrý D, Oborník M, Šlapeta J, Lukeš J, et al. Apicomplexa. In: Archibald J, et al., editors. Handbook of the Protists. Cham: Springer International Publishing; 2016. pp. 1–58.*
4) Frischknecht, F., & Matuschewski, K. (2017). *Plasmodium* Sporozoite Biology. *Cold Spring Harbor perspectives in medicine*, *7*(5), a025478. https://doi.org/10.1101/cshperspect.a025478
5) Prudêncio, M., Rodriguez, A., & Mota, M. M. (2006). The silent path to thousands of merozoites: the Plasmodium liver stage. *Nature reviews. Microbiology*, *4*(11), 849–856. https://doi.org/10.1038/nrmicro1529
6) Sturm, A., Amino, R., van de Sand, C., Regen, T., Retzlaff, S., Rennenberg, A., Krueger, A., Pollok, J. M., Menard, R., & Heussler, V. T. (2006). Manipulation of host hepatocytes by the malaria parasite for delivery into liver sinusoids. *Science (New York, N.Y.)*, *313*(5791), 1287–1290. https://doi.org/10.1126/science.1129720
7) Gerald, N., Mahajan, B., & Kumar, S. (2011). Mitosis in the human malaria parasite Plasmodium falciparum. *Eukaryotic cell*, *10*(4), 474–482. https://doi.org/10.1128/EC.00314-10
8) Bennink S, Kiesow MJ, Pradel G. The development of malaria parasites in the mosquito midgut. Cell Microbiol. 2016 Jul;18(7):905-18. doi: 10.1111/cmi.12604. Epub 2016 May 24. PMID: 27111866; PMCID: PMC5089571.
9) Siciliano, G., Costa, G., Suárez-Cortés, P., Valleriani, A., Alano, P., & Levashina, E. A. (2020). Critical Steps of *Plasmodium falciparum* Ookinete Maturation. *Frontiers in microbiology*, *11*, 269. https://doi.org/10.3389/fmicb.2020.00269
10) Vaughan J. A. (2007). Population dynamics of Plasmodium sporogony. *Trends in parasitology*, *23*(2), 63–70. https://doi.org/10.1016/j.pt.2006.12.009
11) Smith, R. C., & Jacobs-Lorena, M. (2010). *Plasmodium*-Mosquito Interactions: A Tale of Roadblocks and Detours. *Advances in insect physiology*, *39*, 119–149. https://doi.org/10.1016/B978-0-12-381387-9.00004-X
12) Hedrick PW. Population genetics of malaria resistance in humans. Heredity (Edinb). 2011 Oct;107(4):283-304. doi: 10.1038/hdy.2011.16. Epub 2011 Mar 23. Erratum in: Heredity (Edinb). 2011 Dec;107(6):602. PMID: 21427751; PMCID: PMC3182497.

Pictures:

1) https://en.wikipedia.org/wiki/Plasmodium