First Report of the Physiological Race (XXIV) of *Hemileia vastatrix* (Coffee Leaf Rust) in Hawaii

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Hawaii's coffee industry, produced commercially on six islands by over 1,470 growers on ~10,000 acres, is conservatively valued at $100M per year (USDA NASS 2023). Until late October 2020, Hawaii was the only major coffee producing region of the world that was free of Coffee Leaf Rust (CLR). Growers are currently facing their most formidable production challenge with the arrival of *Hemileia vastatrix* Berk. & Broome, the most economically devastating pathogen of coffee worldwide. Since its introduction (Keith et al. 2022), CLR has rapidly spread throughout the state and can be found on coffee farms and feral coffee throughout the six islands. Implementation of CLR control measures will be difficult in Hawaii, given the extreme environmental heterogeneity, differences in management practices, high production costs, and labor shortages. Compounding these challenges is that all coffee genotypes grown

on a large scale in the state are susceptible to CLR. More than 55 different rust races from coffee growing countries worldwide have been identified (Silva et al. 2022). Since key control measures include developing and establishing resistant coffee cultivars, determining the rust race(s) present in Hawaii was imperative. In June 2021, nine spore samples from symptomatic cultivated and feral plants ('Typica') growing on three islands (Hawaii Island: 3, Maui: 5, Molokai: 1) were collected in gelatin capsules using a G-R Electric Manufacturing portable vacuum pump with a mini cyclone spore adapter. The samples were sent to the Coffee Rust Research Center (CIFC) in Portugal. At CIFC, the urediniospores were bulked on susceptible genotype 849/1 Matari and inoculated on a set of coffee differentials following a standard race-typing procedure (Várzea and Marques 2005). The genotype of virulence of rust samples was inferred according to Flor's gene-for-gene theory (Silva et al. 2022). The genes of virulence v_2, v_4, and v_5 (Race XXIV) were identified in all rust samples from all islands in Hawaii, supporting the theory of a single introduction to the state, which subsequently spread (Ramírez-Camejo et al. 2022). Race XXIV was previously characterized at CIFC and is commonly found in the majority of coffee-growing countries in South and Central America, Africa and Asia (CIFC's data base). According to Figueiredo & Arruda (1974), race XXIV is considered highly aggressive with a high spore germination rate, medium germ tube length, and short incubation period required for infection. Race XXIV is pathogenic to all coffee Arabica genotypes with the resistance genes S_H5 or $S_H2,5$ like varieties Blue Mountain, Bourbon, Catuaí, Caturra, Kent's, Kona, K7, Mundo Novo, SL 28, SL 39, as well as Accession "Agaro" with resistance genes $S_H4,5$ (CIFC's records). On the other hand, this race is not virulent to some other Arabica genotypes, such as Geisha ($S_H1,5$), S.288 ($S_H3,5$), and Dilla & Alghe (S_H1). Race XXIV is unable to infect derivatives of interspecific tetraploid hybrids like the groups Catimor and Sarchimor (Bettencourt and Rodrigues 1988). This is the first report of race XXIV on *Coffea arabica* in Hawaii. This finding is essential to evaluate the potential resistance of coffee germplasm existing in Hawaii or to be introduced in this region to develop new varieties. Since the emergence of new *H. vastatrix* races occur preferentially at germplasm collections (Li et al. 2021), proper management is imperative where multiple genotypes/varieties are planted.

Bettencourt, A. J., Rodrigues, Jr C. J. 1988, In: Clarke RJ, Macrae R (eds), Coffee Agronomy, vol. IV, Elsevier Applied Science Publishers LTD, London and New York, pp 199-234.

Figueiredo, P., Arruda, H. V. 1974, Arquivos do Instituto Biológico 41(1): 47.

Keith, L. M., et al. 2022. Plant Disease 106(2): 761. https://doi.org/10.1094/PDIS-05-21-1072-PDN

Li, L., et al. 2021. Plant Disease 105(12): 4162. https://doi.org/10.1094/PDIS-04-21-0796-PDN

Ramírez-Camejo, et al. 2022, J. Fungi 8(2): 189. https://doi.org/10.3390/jof8020189

Silva, M. C. et al. 2022, Agronomy 12: 326. https://doi.org/10.3390/agronomy12020326

USDA National Agricultural Statistics Service. 2023. https://www.nass.usda.gov/Statistics_by_State/Hawaii/Publications/Fruits_and_Nuts/Coffee_Jan23.pdf

Várzea, V. M. P., Marques, D. V. 2005, In, 'Durable Resistance to Coffee Leaf Rust' (Eds L. Zambolim, E. M. Zambolim, V. M. P. Várzea). pp. 53–74. (Vicosa: Universidade Federal de Vi¸cosa).