

Research Application Summary

**Environmental and social impacts of *Pteridium aquilinum* (L.) Kuhn (Bracken Fern) invasive species growing in Nyungwe Forest, Rwanda**

Senyanzobe, J.M.V.<sup>1</sup>, Mulei, J.M.<sup>1</sup> & Bizuru, E.<sup>2</sup>

<sup>1</sup>University of Eldoret, P. O Box 1125-30100, Eldoret, Kenya

<sup>2</sup>University of Rwanda

**Corresponding author:** nzobe2000@yahoo.fr, josephinemumbe@gmail.com, ebizuru@gmail.com

---

**Abstract**

*Pteridium aquilinum* is a cosmopolitan weed that readily spreads into pasture and marginal areas and is favoured by fire and soil acidity. Its presence reduces land productivity and adversely affects biodiversity. The plant is little affected by animals because of its toxicity. *P. aquilinum* has colonized large areas of the Nyungwe forest in Rwanda that were destroyed by fire. The presence of this plant has negative impacts on environment, biodiversity, and animal and human health due to its toxicity. The plant contains the carcinogenic compound ptaquiloside which has potential of contaminating water resources but also affects growth of other plant species. This study is being carried out to determine the impact of *Pteridium aquilinum* on plant biodiversity and its effect on animal and human health in Nyungwe forest in Rwanda.

Key words: Contaminated milk and consumption, contaminated water, gastric cancer, toxins

**Résumé**

*Pteridium aquilinum* est un adventice cosmopolite qui se répand facilement dans les zones de pâturages et marginales, et est favorisée par le feu et l'acidité du sol. Sa présence présente un effet négatif sur la productivité des terres et nuit à la biodiversité. Elle est peu affectée par les animaux en raison de sa toxicité. *Pteridium aquilinum* colonie de vastes surfaces de la forêt de Nyungwe au Rwanda détruites par le feu. En raison de sa toxicité, la présence de cette plante a aussi des impacts négatifs sur l'environnement, la biodiversité et la santé animale et humaine. La plante contient un composé carcinogène qui a le pouvoir de contaminer les eaux et influencer la croissance d'autres espèces de plante. Cette étude a été conduite pour déterminer l'impact de *Pteridium aquilinum* sur la biodiversité végétale et ses effets sur la santé animale et humaine dans la forêt de Nyungwe au Rwanda.

Mots clés: Lait contaminé et consommation, eau contaminée, cancer gastrique, toxines

---

## Background

Nyungwe National Park provides services and livelihood opportunities for many people in the surrounding communities. However, the continuous illegal use of forest resources (such as hunting, tree cutting, mining, agriculture expansion and honey collection) is gradually leading to forest degradation and the loss of the park's biodiversity. One of the main threats to Nyungwe forest is the spread of wild fires and the subsequent forest degradation. Between 1997 and 1998, fires destroyed more than 12% of Nyungwe's forests. Rainforest plant species are not adapted to wildfire disturbance and many species grow very slowly or require large amounts of rain for quicker growth. Dense ferns (*Pteridium aquilinum*) grow quickly in burned areas, preventing seedlings from other species from growing, which is why burned areas can remain treeless for decades.

After a wildfire, the forest soil is quickly colonized by a thick, persistent layer of ferns, which thrive in disturbed areas. The ferns dominate, impeding the ability of other wild species to germinate. Fern colonization is long lasting. Most of the forest affected by the 1997 fires is still covered by ferns. The areas colonized by ferns have very little value as wildlife habitat, thus reducing the already limited resources available ([www.wcs.org/Rwanda](http://www.wcs.org/Rwanda)). Nyungwe forest's diverse floral species include the giant forest fern.

Rwanda is divided into two major drainage basins, the Nile to the east and the Congo to the west. Thus, the forested area of Nyungwe is Rwanda's major watershed for both the Nile and the Congo basins and their water has a direct influence on life of people and animals that use it (Rwanda ETOA, 2008).

## Literature summary

Ptaquiloside is the major toxin of bracken, and was first isolated in 1983. Its chemical stereostructure was determined to be norsesquiterpene glucoside of illudane type by Yamada and co-workers (Niwa *et al.*, 1983). The carcinogenicity of ptaquiloside was proven in 1984 (Hororo *et al.*, 1984; 1987) and ptaquiloside was shown to be responsible for the characteristic biological effects of bracken, such as acute bracken poisoning, bright blindness in sheep, mutagenicity, clastogenic effects and genotoxicity (Shabin *et al.*, 1998).

In 2004, Danish scientist Lars Holm Rasmussen released results of a study showing that the chemical can leach from the plant into the water supply, which may explain an increase in the incidence of gastric and oesophageal cancers in humans in bracken-rich areas (Rivillious and Kate, 2012). In addition, livestock have been known to eat the young shoots and fronds, which can then cause cancer in the animals, especially when untreated. Ptaquiloside has been identified in the milk of cows and groundwater. Humans can be exposed by direct consumption of the plant, contaminated water or milk, and spore inhalation (Gomes *et al.*, 2012).

Bracken has been shown to be carcinogenic in some animals and some have suggested it could be playing some part in causing the high incidence of stomach cancer in Japan (Evans

*Fifth RUFORUM Biennial Regional Conference 17 - 21 October 2016, Cape Town, South Africa* 149  
*et al.*, 1971). The plant is carcinogenic to animals such as mice, rats, horses and cattle when ingested, although they will usually avoid it unless nothing else is available. Young stems are quite commonly used as a vegetable in China, Japan and Korea. However, some researchers suspect a link between consumption and higher stomach cancer rates. The spores have also been implicated as a carcinogen (Evans *et al.*, 1971).

In cattle, bracken poisoning can occur in both an acute and chronic form, acute poisoning being the most common. In pigs and horses bracken poisoning induces vitamin B deficiency. Poisoning usually occurs when there is a shortage of available grasses such as in drought or snowfalls (Auld *et al.*, 1992). The main objective of the study is to determine the impact of *Pteridium aquilinum* on plant biodiversity and its effect on animal and human health.

### **Study description**

The study will focus on the low to middle elevation (1,500-1900m asl) of the forest in the fern trail called “igishigishigi” trail where tree ferns and associated tall tree species such as *Carapa*, *Entandophragma*, *Newtonia*, *Polycscias*, *Symphonia*, *Cyathea manniana* are present. Water originating from the forest will be sampled from rivers, water treatment plant, underground water and lakes and analyzed for the presence of ptaquiloside by hydrolysis method. Sampling will be done both in the dry season and wet seasons. Levels of ptaquiloside will be compared to the set standards.

The soil from the study site will also be sampled and analyzed for pH and ptaquiloside. For vegetation analysis, selective sampling will be used to determine plant species composition and diversity in areas dominated by the fern. Plant species will be identified using botanical features. Data will be subjected to the Chi square test.

### **Acknowledgements**

We acknowledge the Government of Rwanda through the University of Rwanda for providing training resources for the first author, the Government of Kenya through the University of Eldoret for providing tuition waiver and accommodation, RUFORUM for funding research and the supervisors for their guidance. This paper is a contribution to the 2016 Fifth African Higher Education Week and RUFORUM Biennial Conference.

### **References**

- Alonso-Amelot, M.E. and Avendano, M. 2001. Possible association between gastric cancer and bracken fern in Venezuela: An epidemiologic study. *International Journal of Cancer* 91 (2): 252-259.
- D’Antonio, C.M., Tunison, JT. and Loh, R.K. 2000. Variation in the impact of exotic grasses on native plant composition in relation to fire across an elevation gradient in Hawaii. *Austral Ecology* 25 (5):507-522.

- Evans, A., Widdop, B., Jones, R.S., Barber, G.D., Leach, H., Jones, D.L. and Mainwaring-Burton, R. 1971. The possible human hazard of the naturally occurring bracken carcinogen. *Biochem J.* 124 (2): 29-30.
- Grime, J.P., Hodgson, J.G. and Hunt, R. 1988. Comparative plant ecology. A functional approach to common British species. London, UK: Unwin Hyman Ltd.
- Douglas, G.W., Straley, G.B. and Meidinger, D. 1991. The vascular plants of British Columbia Part 3 - Dicotyledons (Primulaceae through Zygophyllaceae) and Pteridophytes. <http://www.for.gov.bc.ca/hfd/pubs/Docs/Srs/Srs03/Srs03-3.pdf>.
- Hirono, I., Aiso, S., Yamaji, T., Mori, H., Yamada, K., Niwa, H., Ojika, M., Wakamatsu, K., Kigoshi, H., Niiyama, K. and Uosaki, Y. 1984. Carcinogenicity in rats of ptaquiloside isolated from bracken. *Gann* 75 (10): 833–836.
- Hirono, I., Ogino, H., Fujimoto, M., Yamada, K., Yoshida, Y., Ikagawa, M. and Okumura, M. 1987. Induction of tumors in ACI rats given a diet containing ptaquiloside, a bracken carcinogen. *Journal of the National Cancer Institute* 79 (5): 1143–1149.
- Niwa, Haruki, Ojika, Makoto, Wakamatsu, Kazumasa, Yamada, Kiyoyuki, Hirono, Iwao and Matsushita, Kazuhiro 1983. Ptaquiloside, a novel norsesquiterpene glucoside from bracken, *Pteridium aquilinum* var. *latiusculum*. *Tetrahedron Letters* 24 (38): 4117–4120. doi:10.1016/S0040-4039(00)88276-3.
- Potter, D.M. 2000. Carcinogenic effects of ptaquiloside in bracken fern and related compounds. *British Journal of Cancer* 83 (7): 914–920. doi:10.1054/bjoc.2000.1368.15.
- Shahin, Mahmood, Moore, Michael, R., Worrall, Simon, Smith, Barry L., Seawright, Alan A., Prakash, and Arungundrum, S. 1998. H-ras activation is an early event in the ptaquiloside-induced carcinogenesis: Comparison of acute and chronic toxicity in rats. *Biochemical and Biophysical Research Communications* 250 (2): 491–497. doi:10.1006/bbrc.1998.9341.
- Wesche, K., Miehe, G. and Kaeppli, M. 2000. The significance of fire for Afroalpine Ericaceous vegetation. *Mountain Research and Development* 20:340-347.
- Youta Happi, 1998. Arbres contre graminées: La lente invasion de la savane par la forêt au Centre-Cameroun. Thèse de doctorat, Université de Paris-Sorbonne (Paris IV). [www.bondy.ird.fr/carto/publi/Youta\\_pdf/These\\_Youta.pdf](http://www.bondy.ird.fr/carto/publi/Youta_pdf/These_Youta.pdf).
- [www.en.wikipedia.org/wiki/Pteridium\\_aquilinum](http://www.en.wikipedia.org/wiki/Pteridium_aquilinum)
- [www.cabi.org/isc/datasheet](http://www.cabi.org/isc/datasheet)