

Exploration, abundance and nutrient potential of *Rubus* in Lawu Mountain, Indonesia

W Setiyadi¹, Nandariyah² and MTh S Budiastuti³

¹Post graduate Agronomy Student of Sebelas Maret University, Jl. Ir. Sutami 36A Kentingan Jebres Surakarta 57126, Indonesia

²Agronomy Department of Graduate Program Sebelas Maret University, Jl. Ir. Sutami 36A Kentingan Jebres Surakarta 57126, Indonesia

³Environmental Science Department of Graduate Program Sebelas Maret University, Jl. Ir. Sutami 36A Kentingan Jebres Surakarta 57126, Indonesia

Corresponding author: E-mail: setiyadiwahyu93@gmail.com

Abstract. Along with the Climate Change phenomenon, the presence of *Rubus* began to decrease. However, it is still possible for some *Rubus* species to survive the condition. There are at least six *Rubus* species in Mount Lawu. The six species are *Rubus moluccanus*, *Rubus lineatus*, *Rubus fraxinifolius*, *Rubus rosaefolius*, *Rubus niveus*, and *Rubus rosifolius*. The aims of this research were to initiate stage of *Rubus* conservation due to increasingly irregular climate change. This research used quadratic transect along the hiking route. The fruits used as samples for the antioxidants, vitamin C, and anthocyanin contents analysis. The results revealed that *Rubus moluccanus* were found in post 1 and post 3 via Cetho Temple route with abundance value of 0.16 and 3.3. Meanwhile, *Rubus rosaefolius* and *Rubus rosifolius* only found in post 1 with abundance value of 0.8 and 0.64. The results also showed that *Rubus moluccanus* contains 13.78% antioxidants, 53.17 mg per 100 g vitamin C, and 220 mg per 100 g anthocyanins.

1. Introduction

The western world knows *Rubus* as Raspberry or Bramble. This fruit has become one of the important commodities in Russia, the United States, Britain, Poland, Mexico, Serbia, and many other countries. Based on Oliveira's research [1], *Rubus* have a phenolic compound and biological activities including antioxidant, vitamin C, and anthocyanin. It has a complex phytochemical content that uses in a variety of medicines. Based on a survey conducted by the United Nations Food and Agriculture Organization's Corporate Statistical Database (FAOSTAT) [2], *Rubus*'s production in 2016 reached 795,000 tons spread across Europe and America.

Based on research conducted by Setyawan [3], he found four species of *Rubus*, namely *Rubus lineatus*, *Rubus niveus*, *Rubus rosifolius*, and *Rubus moluccanus*. These four *Rubus* grow a lot on the south side of Mount Lawu where rainfall and humidity are quite high. Mount Lawu is one of the volcanic mountains on the island of Java which lies between two provinces, the province of Central Java and the province of East Java. This mountain has an altitude of 3265 m above sea level. It has different environmental characteristics on each side. The altitude and steepness of the slopes affect the temperature, rainfall, cloud thickness, air humidity, wind speed, sunlight intensity and evaporation [4]. The south side usually bypassed by Southeast winds that contain high humidity. Southeast winds stopped on the south side then moved upwards resulting in a condensation process. This event caused



local rain on the southern slope. The same thing happens on the western slope. This side area of Mount Lawu which exposed to local rain commonly referred to as Rain Storage. The north and east sides of Mount Lawu commonly referred to as Shade of Rain. The high humidity of the southwest wind turns out to be dryness when reached the north and east sides. This condition causes the northern and eastern side of Mount Lawu to appear more arid.

There was a decrease in the distribution and abundance of *Rubus* that grew on Mount Lawu, especially on the Cemoro Sewu route [3]. This becomes a serious condition when this route located on the southern slope which should have high abundance. Mount Lawu is one of the mountains that often experiences fires so that it has the potential to lose germplasm sources in it. Of the several fire incidents on Mount Lawu, two events occurred due to the long dry season in 1997 and 2015. The long dry season in Indonesia usually occurs when Indonesia is passed by tropical storm El-Nino. This situation occurs approximately once every 10 years. Harrison [5] reported that the El-Nino phenomenon in the tropical rainforest of Borneo in 1997 was able to cause death for many plant species, reduced flower and fruit production, extinction of pollinator species, and disruption of ecosystem balance. This *Rubus* abundance study on Mount Lawu needed as an initial stage of *Rubus* conservation, this plants can be immediately saved from extinction due to increasingly irregular climate change.

2. Research method

2.1. Time and place of research

Rubus's exploration conducted along the Mount Lawu climbing route via Cetho Temple and Cemoro Sewu in October 2017 - August 2018. Preliminary research conducted to determine the point for quadratic transects analyzing for *Rubus* and other surrounding plants. The abundance data from 1993-1998 taken from Setyawan's research [3]. The *Rubus* sampling location was carried out in areas where the *Rubus* species grows. Secondary data collected (altitude, latitude, temperature, humidity, light intensity, and soil physical condition) to determine *Rubus* agroecology.

2.2. Morphological analysis

Morphological character observations performed on *Rubus* vegetative and generative organs. The characters observed included qualitative and quantitative characters based on the International Plant Genetic Resources Institute (IPGRI) [6] and factual observation of the *Rubus* conditions found.

2.3. Vegetation analysis

Sampling was carried out using the quadratic transect method, with a square of 5 x 5 meters [7]. Squared transects are designed to follow along with the climbing route of Mount Lawu via Cetho Temple and Cemoro Sewu. Squares made with a systematic distribution where *Rubus* found.

2.4. Proximate analysis

2.4.1. Antioxidant level. *Rubus* samples were taken 1ml in a closed test tube, 4ml of ethanol was added. The absorbance ability measured after 30 minutes with Ultraviolet-Visible (UV-Vis) spectrophotometer at a wavelength of 517nm [8].

2.4.2. Total anthocyanin level. Total anthocyanin analysis was carried out using pH differentiation method. Anthocyanins will change color when in different pH conditions. The color then analyzed using spectrophotometry.

2.4.3. Ascorbic Acid Content. *Rubus*'s sample measured for its absorbance ability after diluted 200 x with an Ultraviolet-Visible (UV-Vis) spectrophotometer at the maximum wavelength.

3. Result and discussion

Setyawan [3] were found four species of *Rubus*, namely *Rubus moluccanus*, *Rubus lineatus*, *Rubus niveus*, and *Rubus rosifolius*. The four species were found in the Mount Lawu climbing route via Cemoro Sewu. The research I conducted in 2017-2018 succeeded in finding six species of *Rubus* from the climbing path of Mount Lawu via Cetho Temple and Cemoro Sewu. The species that found were *Rubus moluccanus*, *Rubus lineatus*, *Rubus fraxinifolius*, *Rubus rosaefolius*, *Rubus niveus*, and *Rubus rosifolius*.

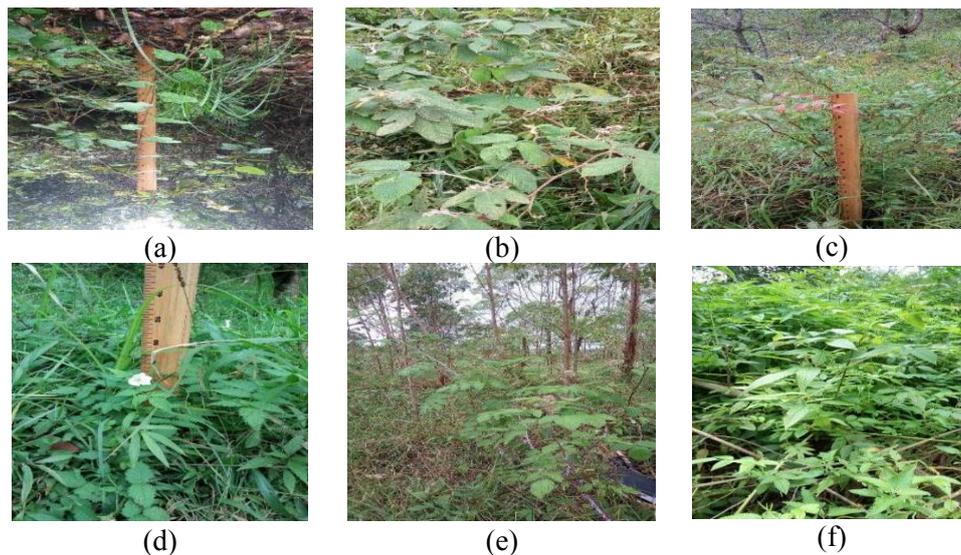


Figure 1. *Rubus* physical appearance ((a) *Rubus moluccanus*, (b) *Rubus lineatus*, (c) *Rubus fraxinifolius*, (d) *Rubus rosaefolius*, (e) *Rubus niveus* and (f) *Rubus rosifolius*)

Figure 1(a) is *Rubus moluccanus*. This species is usually a shrub with a height of 1-3 meters. This species can also be found under large trees and usually climbs along the tree. *Rubus moluccanus* that grows under a tree can reach a height of 10-30 meters [9]. *Rubus moluccanus* leaves are round and form 3-5 tapered (*acuminatus*) edges (*Apex Folia*) with double serrated (*biserratus*) leaf edges (*Margo Folia*). The leaves have *palminervis* (finger-like) skeleton. Young stems, upper and lower layers of leaves covered in fine hairs (*pilus*). This hair serves to reduce evaporation when the temperature drops dramatically at night [10]. The mature *Rubus moluccanus* stem is brown with quite a few small spines, while the young stems are shiny green with small spines. Adult stems have a diameter between 1-3 cm.

Figure 1(b) is *Rubus lineatus*. This species is usually a shrub with a height of 1-3 meters. *Rubus lineatus* leaves are very unique with leaf skeleton running with fingers (*palminervis*) between 3-5 pieces. Serrated leaf edges (*serratus*) with tapered (*acuminatus*) leaf tips. Mature leaves are dark green and young leaves are light green. The top and bottom leaves coated with fine hair (*pilus*). Leaf stalks are sometimes green or purple with fine hair and some spines. The leaf's protective organs (*stipula*) are well developed. *Rubus lineatus* stems have soft, dense hair when they are young and brown woody when they are mature. There are small purple thorns that are quite a lot on both old and mature stems. Adult stems have a diameter of 2-3 cm. Fine hair on this stem serves to reduce evaporation at high temperatures. Small spines function as a defense of *Rubus lineatus* against primate pests that attempt to take their fruit.

Figure 1(c) is *Rubus fraxinifolius*. It is one type of *Rubus* that found in several regions in Indonesia, such as in Kalimantan, Java, Sulawesi, and Bali [11]. Usually grows clustering between 1-5 trees in an area. Mature trees in the form of medium branched shrubs with a height ranging from 1-2 meters. This type of *Rubus* has been cultivated at Cibodas Botanical Garden, Bogor, West Java [12]. In the case of

leaf color, *Rubus fraxinifolius* has a unique color gradation depending on the environmental conditions in which this type of *Rubus* grows. The leaves can be dark green, light green, red, to purple. Advanced leaves with the number of leaves 4-10 pieces. Pinnate leaf skeleton with leaf stems is overgrown with spines. The upper and lower leaves look shiny without fine hair. Serrated leaf edges with tapered leaf tips. Mature stems and young stems are not covered by fine hair. There are thorns that are red and very sharp. Young stems are green, while mature stems are greenish brown. The stem diameter ranges from 1-2 cm.

Figure 1(d) is *Rubus rosaefolius*. It is a type of bush-shaped *Rubus*. The maximum height of this species only reaches less than 1 meter. *Rubus rosaefolius* is usually often annihilated because it is considered a weed or a pest. When it finds a suitable growing place, it will grow vegetatively with adventitious shoots, very quickly.

Figure 1(e) is *Rubus niveus*. It has a purple fruit which tastes sweeter and fresher when ripe compared to other *Rubus* species on Mount Lawu. The distribution of *Rubus niveus* very limitly on Mount Lawu. The flowering time of *Rubus niveus* is relatively different from other *Rubus* species that found on Mount Lawu.

Figure 1(f) is *Rubus rosifolius*. *Rubus rosifolius* is one type of *Rubus* which is very difficult to distinguish in terms of morphology with *Rubus rosaefolius*. At first glance, *Rubus rosifolius* also has habitat characteristics similar to *Rubus rosaefolius*. One that distinguishes *Rubus rosaefolius* and *Rubus rosifolius* is the size of the tree and the shape of the fruit. *Rubus rosifolius* has a higher tree. *Rubus rosifolius* tree has a character similar to *Rubus fraxinifolius*. *Rubus rosifolius* fruit has a smaller amount of fruit, while *Rubus rosaefolius* has a larger and juicy fruit.

Table 1. Parameters of environmental observation at the location of the discovery of *Rubus* on Mount Lawu

Species	Location found	Altitude (m asl)	Tem p. (°C)	Air (%) humidity	light (lux) intensity	Soil condition		amount
						pH	moist.	
<i>R. moluccanus</i>	Cetho Temple	stat*1: 1520	23.02	73	4350	06.02	4	2
		stat*3: 1658	23.04	76	13240	05.02	6	25
	Cemoro Sewu	stat*1: 1927	20.04	83	9009.39	05.09	6	1
		stat*2: 1950	21.09	81	10699.3	06.08	6	2
<i>R. lineatus</i>	Cemoro Sewu	stat*3: 1976	23.06	81	10.76	05.02	8	1
		stat*2: 1950	21.09	81	10699.3	06.08	6	2
		stat*3: 1976	23.06	81	10.76	05.02	8	2
<i>R. fraxinifolius</i>	Cemoro Sewu	stat*2: 1950	21.09	81	10699	06.08	6	1
		stat*3: 1976	23.06	62	8212.86	06.03	2	1
		stat*4: 2085	25.01	62	8212.86	06.03	2	43
<i>R. rosaefolius</i>	Cetho Temple	stat*1: 1520	23.06	73	4350	06.02	4	10
<i>R. niveus</i>	Cetho Temple	stat*2: 1625	23.08	73	4350	06.02	4	1
	Cemoro Sewu	stat*5: 2129	23.05	67	6792.03	06.01	7	3
<i>R. rosifolius</i>	Cetho Temple	stat*1: 1520	23.06	73	4350	06.02	4	8
	Cemoro Sewu	stat*2: 1950	21.09	81	10699	06.08	6	1

*stat: Observation Station

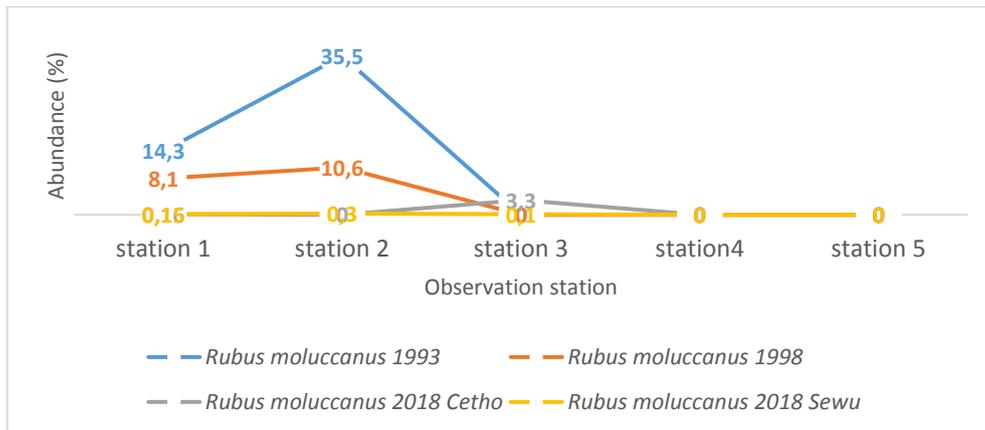


Figure 2. Vegetation analysis of the presence of *Rubus moluccanus* on Mount Lawu.

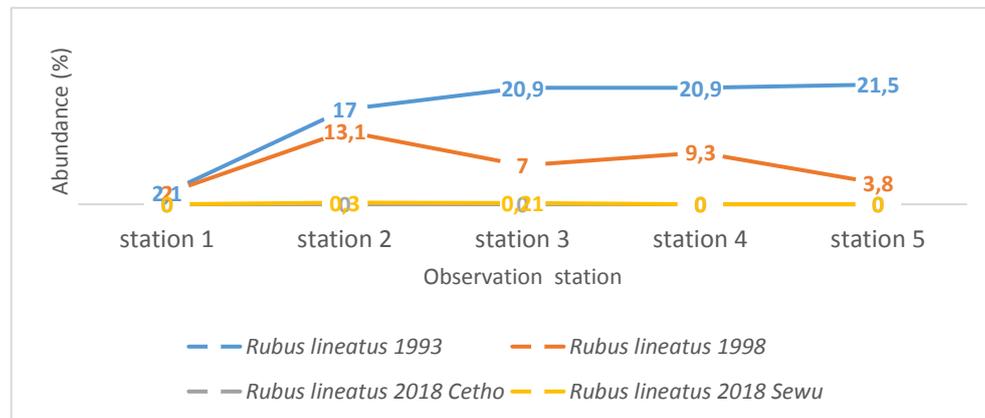


Figure 3. Vegetation analysis of the presence of *Rubus lineatus* on Mount Lawu

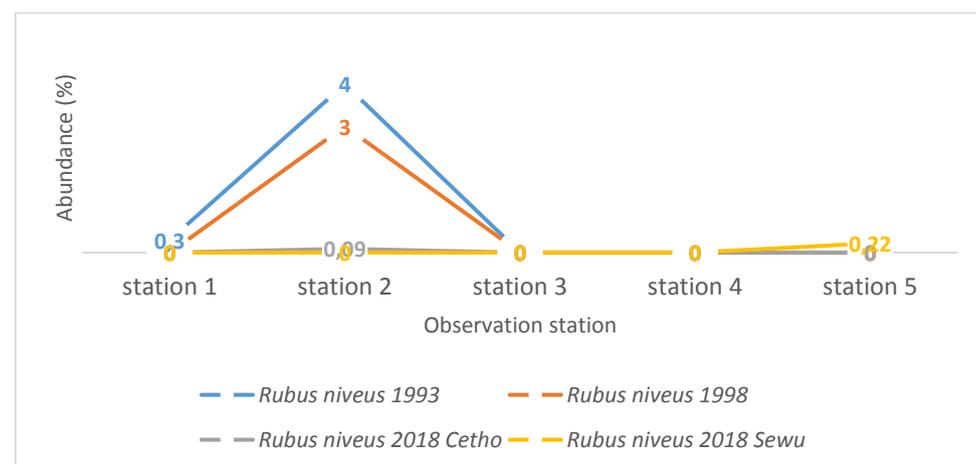


Figure 4. Vegetation analysis of the presence of *Rubus niveus* on Mount Lawu

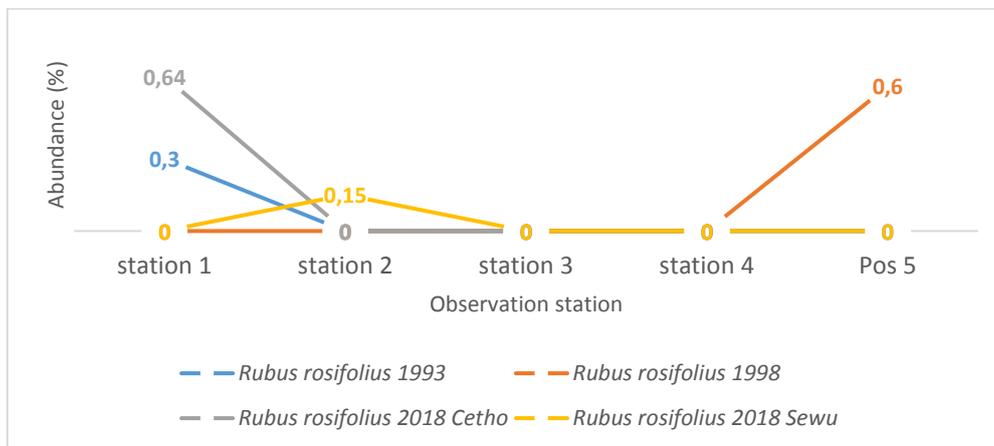


Figure 5. Vegetation analysis of the presence of *Rubus rosifolius* on Mount Lawu

Figures 2, 3, 4, and 5 compare the abundance of four *Rubus* species, *Rubus moluccanus*, *Rubus lineatus*, *Rubus niveus*, and *Rubus rosifolius*. Figure two shows that the presence of *Rubus moluccanus* decreases after post 2 and is not found later in the next post. Its abundance at all times of research also decreases. This proves that the abundance, distribution, and existence of *Rubus moluccanus* has greatly reduced since 1993 until 2017-2018 on the same climbing route, namely the Cemoro Sewu climbing route. The same thing happened to the Cetho Temple climbing route where its abundance was relatively similar to the abundance of *Rubus moluccanus* in Cemoro Sewu in the same year.

Figure three shows that *Rubus lineatus* requires habitat to grow at low temperatures. This is indicated by graphs that tend to go up from station 1 to station 2. In the research that conducted in 2017-2018, the increase in abundance also occurred from station 1 to station 2, but it tends to go down after passing the next post. Even in the Cetho temple climbing route *Rubus lineatus* cannot be found. In figure three, it concluded that in the three study periods the abundance of *Rubus lineatus* tends to decrease.

Figure four shows that *Rubus niveus* had considerable abundance in 1993 and 1998, but its abundance dropped dramatically in 2017-2018. The same thing happened to *Rubus rosifolius*. Figure four shows that this type of *Rubus* only found in small and not evenly distributed abundance values.

Although Setyawan [3] was unable to find *Rubus fraxinifolius* and *Rubus rosaefolius*, the abundance of these two species was very small in the 2017-2018 study. In the 1993 and 1998 studies, it was known that the abundance of four other *Rubus* species had decreased but the distribution was relatively similar. In 2017-2018, it turned out that the distribution of the four types of *Rubus* tended to be different and their abundance much reduced. This is most likely due to two major fires that occurred in 1997 and 2015 which caused some areas of Mount Lawu to experience succession. The event of this succession caused differences in plant species diversity at the time before the fire event and afterward. Two major fire incidents occurred because at that time Indonesia was hit by a long dry season due to tropical storm El-Nino [6]. This storm brings dry wind that does not contain moisture. In addition to the two major fires in 1997 and 2015, Mount Lawu also experienced significant fire incidents. Most of these fires caused by significant climate change. The temperature around Mount Lawu increases sharply during the dry season. *Rubus* is a plant that is very sensitive to temperature rise. climate change causes temperature instability in Mount Lawu. temperatures tend to increase and threaten the habitat of *Rubus*.

Table 2. Rubus nutrient potential in Mount Lawu

No	Rubus species	Location found	Altitude (m asl)	Antioxidant content (%)	Vitamin C (mg per 100g ⁻¹ *)	Anthocyanin (mg per 100g ⁻¹ *)
1	<i>Rubus moluccanus</i>	Cetho Temple	1658	13.78	57.13	220.49
2	<i>Rubus fraxinifolius</i>	Cemoro Sewu	2085	19.07	88.68	452.44

Although there are six species of Rubus that can be found on Mount Lawu, not all species able to produce flowers or fruit. Based on the observations on the Mount Lawu climbing route via Cetho Temple, only one Rubus species found which could bear fruit and fulfill the minimum amount to be carried out research on the nutrient content in it. Rubus species that can bear fruit quite dense on the climbing route via the Cetho Temple are *Rubus moluccanus*. As one of the wild plants that have low abundance values, *Rubus moluccanus* is relatively high in the percentage of antioxidants, vitamin C and anthocyanins. Table 2 shows that *Rubus moluccanus* contains 13.78% antioxidants, 57.13 mg per 100g⁻¹ of vitamin C, and 220.49 mg per 100g⁻¹ of anthocyanins. Abu Bakar [13] reports that *Rubus moluccanus* has high antioxidant activity and contains phenolic compounds, flavonoids, and carotenoids which are quite high. Based on the results mentioned above, it concluded that *Rubus moluccanus* has the potential as a fruit plant and a drug that has high nutritional value.

Another Rubus species that can bear fruit on the hiking trail via Cemoro Sewu is the *Rubus fraxinifolius* species. *Rubus fraxinifolius* can bear fruit and taken for further research. Table 2 shows that *Rubus fraxinifolius* contains 19.07% antioxidant, 88.68 mg per 100g⁻¹ vitamin C, and 452.44 mg per 100g⁻¹ anthocyanin. Based on Table 2, *Rubus fraxinifolius* has a relatively higher nutritional value than *Rubus moluccanus*. Abu Bakar [13] reports that *Rubus fraxinifolius* has high carotenoid levels. *Rubus fraxinifolius* is also one of the Rubus that has been cultivated in Cibodas Botanical Garden. Surya [12] has conducted a series of studies on the planting of *Rubus fraxinifolius* seeds in several different treatments. In terms of fruit size, *Rubus fraxinifolius* is the largest size of Rubus compared to the other five species on Mount Lawu. Although in this study *Rubus rosaefolius* could not be found with enough fruit for proximate analysis, Oliveira [14] reported that *Rubus rosaefolius* contained high antioxidant and antimicrobial activity. Reategui [15] reported that wild blackberries have high antioxidant activity when extracted by high-temperature methods. *Rubus niveus* is one type of wild blackberry on Mount Lawu. *Rubus niveus* is also one of the most delicious fruit types of Rubus compared to five other species found on Mount Lawu.

4. Conclusion

Six species of Rubus found, *Rubus moluccanus*, *Rubus lineatus*, *Rubus fraxinifolius*, *Rubus rosaefolius*, *Rubus niveus*, and *Rubus rosifolius*, where four species found and their abundance discovered in 1993 and 1998. The four species that were known to grow in Cemoro Sewu hiking route are *Rubus moluccanus*, *Rubus lineatus*, *Rubus rosifolius*, and *Rubus niveus*. The abundance value of Rubus in the climbing route via Cetho Temple and Cemoro Sewu has greatly reduced since 1993-2018 due to climate change on Mount Lawu. *Rubus moluccanus* and *Rubus fraxinifolius* have a high nutritional value that has the potential as a fruit plant and medicinal plant in the future.

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