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SHORT COMMUNICATION

Biomass of *Dendrosenecio keniodendron* leaves in the high mountains of Kenya almost corresponds to their annual productivity

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ABSTRACT

In the high mountains of the Mount Kenya (tropical Africa) the leaf life span of the dominant species of rosette trees *Dendrosenecio keniodendron* was estimated using observations on marked leaves. The intervals between the beginning of leaf expansion and its full death, between the beginning of expansion and the death of 50% of its area, and between 50% leaf length expansion and the 50 % leaf area death were 366±8, 326±18 and 284±17 days correspondingly (mean ± standard error, n=7). As the full leaf life span lasted approximately one year, leaf biomass of this species is considered to be an adequate assessment of its annual production.

Keywords: afroalpine habitats, rosette trees, leaf life span

РЕЗЮМЕ

Онипченко В.Г., Мванги Д., Кипкеев А.М., Копылова Н.А., Елумеева Т.Г. Биомасса листьев *Dendrosenecio keniodendron* в высокогорьях Кении примерно соответствует их годичной продукции. В высокогорьях горы Кения (тропическая Африка) определена длительность жизни листьев доминирующего вида розеточных деревьев *Dendrosenecio keniodendron* методом наблюдений за мечеными листьями. Время от начала развертывания до полного отмирания, от начала развертывания до отмирания 50 % поверхности листа и от 50 % развертывания до 50 % отмирания составило 366±8, 326±18 и 284±17 дней соответственно (среднее и его ошибка, n=7). Поскольку полное время жизни листа составило около года, биомасса листьев этого вида может служить адекватной оценкой его годичной продукции.

Ключевые слова: афроальпийские местообитания, розеточные деревья, длительность жизни листа

The estimation of aboveground productivity in tropical plant communities is rather difficult due to weak seasonality and long leaf life-span (Zhang et al. 2016). For example, detailed observations in Amazonian forests have shown that in trees leaf life span ranges from one year to more than eight years (Reich et al. 2004), while seasonal pattern of leaf expansion is almost not expressed. The estimation of dominant species leaf life span in tropics is an important task, therefore in the tropical high mountain habitats there are few studies on this question. For example, leaf life span of paramo shrubs in Ecuador ranged form 2.7 to 22 months (Diemer 1998).

Longer leaf life span is commonly associated with a low specific leaf area (SLA) and a high leaf density (Wright et al. 2002, Shipley et al. 2005, Mediavilla et al. 2008), which in turn are linked with the development of defensive mechanical tissues, low water conductivity and low assimilation rate (Simonin et al. 2012, Poorter et al. 2013, Bloom et al. 2016, He et al. 2019). "Leaf economy spectrum" reflects the trade-offs between leaf life span and maximum assimilation rate (Messier et al. 2017), which is limited by low night temperatures, high day insolation and low CO_2 partial pressure at the high altitudes of tropics.

The species of the genus *Dendrosenecio* (Hauman ex Hedberg) B. Nord. are the dominants of high mountain communities in the Eastern Africa (Gizaw et al. 2022) (Fig. 1a). They belong to the particular life form known as "rosette trees", which is well represented in tropical high mountains of Africa and South America. In the upper part of poorly branched stem there is a rosette of large leaves (Fig. 1b). *Dendrosenecio keniodendron* (R.E. Fr. & T.C.E. Fr.) B. Nord. is the most common species in the upper part of the alpine belt of the Mount Kenya (Hedberg 1964). This is a monocarpic plant which grows for decades (and, possibly, centuries) before flowering (Fig. 1c), and after flowering the reproductive rosette shoot (stem) dies. It has large leaves with the area of ca. 700 cm^2 and the dry mass of 14 g with a very low specific leaf area of 50 cm^2/g (Onipchenko et al. 2023). So, we can expect a considerable leaf life span of this species, but real values are absent in the literature. Thus, the aim of the present work was to study the leaf life span of this dominant of afro-alpine plant communities.

MATERIAL AND METHODS

The study site is located at the western macroslope of the Mount Kenya in the Teleki valley. The Mount Kenya is a former volcano with a maximum altitude of 5199 m a.s.l. The Teleki valley has a glacial origin and is close to equator (00°10'S 37°18'E). The field observations took place in the upper alpine belt at ca. 4200 m a.s.l. Rocks of the volcanic massif consist of basalt, phonolite, kenytes, agglomerates, trachyte and syenite (Mahaney 1990, Bhatt 1991). Alpine soils are structureless, with a lot of stones, carbon content in fine fraction is 7–15 %, pH of 4.9–5.1, total N 0.8–0.9 %, extractable P 25–55 mg/kg (Coe 1967, Onipchenko et al.

Figure 1 *Dendrosenecio keniodendron* (R.E. Fr. & T.C.E. Fr.) B. Nord. at high elevations of Mt. Kenya: A – an alpine site dominated by *D. keniodendron*, where it contributes more than 50 % to the aboveground biomass; B – an individual plant with a vegetative rosette; C – reproductive shoot; D – expanding leaves of *D. keniodendron*, the youngest leaves are masked by just expanded leaves; E – marked well-developed leaf without signs of dying; F – marked leaf with signs of the beginning of leaf blade dying

2023). The annual mean temperature at 4191 m is 1.7°C with a mean daily range of 9°C for January and July. Mount Kenya has two relatively wet seasons and two more dry seasons as a result of the monsoon with a total annual precipitation up to 2500 mm per year (Coe 1967).

There are several approaches to the leaf life span assessment. Cornelissen and Thompson (1997) considered life span as a time interval between leaf appearance to full dying. However, positive assimilation begins when the leaf reaches ca. half of its maximum height, and finishes after dying of 50 % its area (Maksymowych 1990, Pantin et al. 2012), so photosynthetically active leaf life span is considerably shorter (Craine et al. 1999). In this study we studied several age traits of leaves.

In the tropical high mountains of the Mount Kenya (the Teleki valley), in the March 2018 we selected seven trees with a well-developed rosette (Fig. 1a,b). Among developing leaves we marked one leaf up to 2 cm long (adult leaves are 40–50 cm long). Later we get photos of the marked leaves every 1–2 months (Fig. 1e–f). Assuming the constant rates of growth and death of the leaf blade between observation dates, leaf life span values were calculated for the obtained data. For example, if 07 May 2018 the leaf reached 40 % of the adult leaf length, and 24 June it reached 60 %, than 50 % of the adult leaf length fell on 01 June (the date in the middle of the interval). In total, ten observations were obtained in the period of 29.03.2018 – 18.04.2019. At the final date, all the marked leaves were fully died. The

mark (small hole with a stick) had no effect on the leaf development, as the observed leaves did not differ from neighboring leaves with the similar dates of expansion.

RESULTS AND DISCUSSION

We calculated three leaf life span values (Table 1):

1) the interval between the beginning of expansion and the full death;

2) the interval between the beginning of expansion and the death of 50% of its area;

3) the interval between 50% leaf length expansion and the 50% leaf area death.

These values were in average 366, 326 and 284 days, correspondingly. Thus, the full leaf life span of *Dendrosenecio keniodendron* was approximately one year, and the period of the high assimilation activity lasted ca. 9.5 months.

Life span of long-living leaves is linked both with their density and other mechanical properties (Wright et al. 2002, Choler 2005, Mediavilla et al. 2008, He et al. 2019), and with the time of its active life – assimilation activity during the growing season (Kikuzawa & Kudo 1995). In our case, these values are similar, because the growing season in the tropical high mountains of Africa lasts whole the year (during the days), while interrupting during nights in darkness and under low night temperatures. Leaf life span of herbaceous summer-green plants in the temperate high mountains usually does not exceed one growing season. For example, in the Rocky Mountains leaf life span of perennial herbs is 2–2.5 months (Monson et al. 2001), in summer-green alpine plants of the Caucasus it ranges from one to three months (Erkenova 2012). In the temperate high mountains with a seasonal climate, leaf life span of evergreen plants reaches 2–3 growing seasons (Murray & Miller 1982, Jonasson 1989, Kikuzawa & Kudo 1995), that often corresponds to 6–8 months of active assimilation. For the shrubs belonging to Asteraceae family, in the high mountains of the tropical Ands there was observed a wide life span range of relatively small leaves: from 2.7 to 22 months. In average, the species belonging to 5 genera had 8.6 months life span, and only one genus, *Loricaria*, with leaves of 0.1 cm^2 and more, had leaf life span longer than 10 months (Diemer 1998). Thus, the relatively high period of leaf functioning in alpine tropical Asteraceae species is not exclusive, but at the first time it was shown for large-leaved species of rosette trees in the Africa.

Some studies notice the negative relationship of leaf life span with the rate of photosynthesis and leaf nitrogen content (Ordonez et al. 2010, Poorter et al. 2013, Bucher & Römermann 2021). This is apparently true for the studied species. Leaf nitrogen content of *D. keniodendron* is low and estimated as 1.54 % (Onipchenko et al. 2023), that is substantially lower than in herbaceous species of Asteraceae in the high mountains of the Alps, there the mean for 37 species is 2.6 % (Körner et al. 2016). The known record holder on the leaf life span in the alpine belt of the Ands, *Loricaria*, has very low nitrogen content (1.07 %), while the other Asteraceae species with shorter leaf life span contain more nitrogen – 2.15 % in average (Diemer 1998). Thus, our data confirm the general pattern of leaf nitrogen decrease with an increase in leaf longevity.

Table 1. The estimations of leaf life span values of *Dendrosenecio keniodendron* (days, n=7). SE – standard error. Min, Max – minimum and maximum values.

Period (days)	Mean	SE	Min	Max
Beginning of expansion – full death	366	8	322	382
Beginning of expansion – leaf area 50% death	326	18	222	362
Leaf length 50% expansion – leaf area 50% death	284	17	190	325

The estimation of productivity in the tropical high mountains is of particular interest. The order of magnitude of annual production is apparently close to that of temperate high mountains. However, when estimated per month of the growing season, the production here substantially differ from that of the most of terrestrial intact natural communities – ca. 200 g/m^2 per month (Körner 1999). The obtained close to one year values of leaf life span of the main dominant *D. keniodendron* allows to further productivity assessment of this unique ecosystems using the aboveground biomass.

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