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MINI REVIEW

Conservation relevance of terrestrial herbaceous vegetation studies

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Abstract

Herbaceous vegetation studies are pivotal for a better understanding of the ecology of several animal species that use these plants as food items, nest-building materials, and tools. This article illustrates how such investigations can build on the knowledge base required for conservation planning and help to assess habitat quality. Although many descriptive studies on herbaceous plants used by animals have been carried out, more research effort is needed to address questions such as diversity, community composition, population dynamics, and the influence of abiotic factors. This investment would result in more accurate estimations of resource availability and a better understanding of the effects of abiotic factors on herbaceous plants and dependent animal species.

Keywords: terrestrial herbaceous vegetation; food availability; plant-animal interactions; indicator species; biodiversity monitoring

Primatologists and conservation biologists have carried out ecological studies of herbaceous plants in several sites in Africa to assess the implications of resource availability to dependent animal species (Rogers & Williamson, 1987; Rogers, Williamson, Tutin, & Fernandez, 1988; Malenky, Wrangham, Chapman, & Vineberg, 1993; White, Rogers, Tutin, Williamson, & Fernandez, 1995; Fay, 1997; Furuichi, Inagaki, & Angoue-Ovono, 1997; Brugiere & Sakom, 2001; Doran *et al*., 2002; Head, Boesch, Makaga, & Robbins, 2011). This paper describes the use of herbaceous plants by some mammals and briefly explains how herbaceous plant studies can inform conservation planning. The article also illustrates the relevance of herbaceous plant studies to forest ecology and monitoring. Lastly, the limitations of previous studies are highlighted, and relevant research topics required to further knowledge are suggested.

Herbaceous plants are useful resources for several animal species. For example, herbaceous plants provide staple fallback foods and nest-building materials for gorillas (Tutin, Parnell, White, & Fernandez, 1995; Fay, 1997; Mehlman & Doran, 2002; Ganas, Robbins, Nkurunungi, Kaplin, & McNeilage, 2004; Rogers *et al*., 2004; Harrison & Marshall, 2011; Willie, Tagg, Petre, Pereboom, & Lens, 2014). Herbaceous plants also provide fallback foods for chimpanzees (Harrison & Marshall, 2011). In addition, chimpanzees occasionally sleep in ground nests built using herbaceous plants (Koops, Humle, Sterck, & Matsuzawa, 2007; Tagg, Willie, Petre, & Haggis, 2013). Both chimpanzees and bonobos frequently utilize plant materials, including herbaceous species, to make tools to extract termites from termite nests (Deblauwe, Guislain, Dupain, & Van Elsacker, 2006; McGrew *et al*., 2007; Sanz & Morgan, 2007). Bonobos incorporate a large amount of pith from high-quality herbaceous plants in their diet (Harrison & Marshall, 2011). Aside from great apes, elephants and other mammals such as mandrills, buffalos, bongos, duikers and sometimes arboreal monkeys also consume herbaceous plants (Rogers & Williamson, 1987; Tutin, White, & Mackanga-Missandzou, 1997).

Studies of herbaceous plants can help to assess the ecological interactions between these plants and the animals that depend on them, therefore establishing a link between resource availability and use (Fay, 1997). For example, information on the distribution of the resources used by gorillas may help to identify their preferred habitats (Rogers *et al*., 2004), thus furthering knowledge

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required for conservation planning. Furthermore, thorough investigations of herbaceous plants provide additional evidence to help verify whether fluctuations in herb availability can explain documented changes in the consumption of herbs and the use of habitats by gorillas (Rogers *et al*., 1988; Williamson, Tutin, Rogers, & Fernandez, 1990; Tutin, Fernandez, Rogers, Williamson, & McGrew, 1991; White *et al*., 1995). In addition, understanding the effects of environmental factors on herbaceous plants used by gorillas is particularly important because climate change can negatively affect food sources, thus threatening the existence of these critically endangered apes (Walsh *et al*., 2008; Musana & Mutuyeyezu, 2011). In general, such investigations can help to assess possible influences of meteorological conditions on resource availability to animals relying on herbaceous plants and highlight the abiotic factors that also influence animal ecology, thus contributing to the global picture of how climate change may affect the biotope and the resulting consequences on the faunal community.

On the other hand, herbaceous plants can be used as indicators of habitat quality. The use of indicator species has been proposed as an efficient method for assessing forest quality (e.g. Moffatt & McLachlan, 2004) as their presence reveals the predominance of specific environmental conditions and disturbance regimes (White & Edwards, 2000; Webb, Van de Bult, Chutipong, & Kabir, 2006). For example, detailed studies on herbs have been suggested in order to highlight their importance as indicator species to help define the successional status of secondary forests (Djoufack, 2003). Studying the composition and diversity of herbaceous plants, therefore, may contribute to the definition of ecological indicators of forest development for different successional stages (Moffatt & McLachlan, 2004), and enhance knowledge of forest ecology. In addition, ecological studies on understory herbs can provide some baseline data needed to monitor changes in forest biodiversity (FAO, 2005). Collecting quantitative data on plots or transects to monitor forests is challenging due to constraints such as limited availability of funding, logistics, and time (Nagendra & Ostrom, 2011). Indicator species therefore have a practical importance: knowledge of these species may help to avoid the need for full forest inventories and can provide conservationists with readily available and effective management tools for monitoring and mitigation of human-induced disturbances in natural habitats (Moffatt & McLachlan, 2004), which are serious threats to the survival of critically endangered mammals (e.g. western lowland gorillas; Walsh *et al*., 2008). Furthermore, the study of the composition of herbs in different forest types may help to verify if the occurrence of forest understory herb species in various habitat types can be validated as distinct community types (McCune & Grace, 2002). This knowledge, and additional information on diversity and abundance of herbaceous plants, may help to assess whether these plants can serve as effective criteria for arbitrary classification of forest types in categories.

Research into terrestrial herbaceous vegetation with respect to primate ecology and conservation has been conducted over the last three decades. Rogers and Williamson (1987) measured stem density and available food biomass from pith and shoots of Marantaceae and Zingiberaceae (collectively termed terrestrial herbaceous vegetation, THV, in the study) in a restricted portion of the Lopé Reserve (Gabon). Although THV fruits are also eaten by gorillas (Sabater Pi, 1977; Calvert, 1985; Kingdon, 1997), their biomass could not be included since the THV stems did not have fruit in the dry season when the survey was conducted; nor could they estimate food biomass from new leaves of THV. Rogers *et al*. (1988) monitored the production of young leaves of a few THV species, but THV density was not measured. To fill these gaps, White *et al*. (1995) re-measured THV densities in more representative samples and seasonally monitored the production phenology of THV plant organs, including fruits and leaves. This resulted in a more accurate estimation of THV food availability for gorillas in this site. Fay (1997) later argued that the THV definition adopted by both studies (Rogers & Williamson, 1987; White *et al*., 1995) was too restrictive, especially as species from other monocotyledon families also provide food to many forest herbivores, and they constitute important elements of the herbaceous layer. Therefore in Ndakan (Central African Republic), Fay (1997) described the patterns of abundance, distribution and food availability of THV, including all other terrestrial species of monocotyledons, to have a more complete picture of their occurrence. However, the production phenology of herbs was not monitored. In other sites, herb availability was assessed as part of a global study, and these investigations were limited to stem density estimation (e.g. Malenky *et al*., 1993; Furuichi *et al*., 1997; Brugiere & Sakom, 2001; Doran *et al*., 2002; Head *et al*., 2011). Although many attempts have been made to study THV, less effort has been made to describe other ecological patterns (e.g. diversity, community composition, and population dynamics) or the effects of abiotic factors such as meteorological conditions and soil fertility. Food biomass has been estimated using stem-density data measured during a given period of the year (e.g. Rogers & Williamson, 1987; Fay, 1997). Although this approach can provide an accurate estimation of biomass at the time of the survey, it does not assess temporal variations of food availability; especially if THV stem density, fruit or shoot availability vary throughout the year. In most cases, the estimation did not account for changes in population size because the abundance of THV stems was not monitored throughout the year. Monitoring is therefore needed to provide seasonal THV stem-density data. These data could

be applied to potential food-biomass figures for each species to obtain a more precise assessment of THV food availability at any given moment of the year.

To summarize, it appears that considerable scientific attention has focussed on herbaceous plants used by mammals. However, most investigations were limited to stem density and food biomass from a restricted number of species over short periods. Less effort has been invested to describe other ecological patterns such as diversity, community composition, population dynamics, and the influence of abiotic factors. These limitations have resulted in inaccurate estimations of resource availability. Future research effort should therefore aim to fill these gaps in order to provide a more accurate picture of resource availability and highlight the effects of environmental factors on herbaceous vegetation and dependent animal species.

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