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PROVISIONAL CHECKLISTS OF FLORA AND FAUNA OF THE SAN FRANCISCO VALLEY AND ITS SURROUNDINGS

(RESERVA BIOLÓGICA SAN FRANCISCO, PROV. ZAMORA-CHINCHIPE, SOUTHERN ECUADOR)

01 GENERAL INTRODUCTION

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The Andes of Ecuador are considered one of the "hottest" hotspots of vascular plant biodiversity worldwide (Jørgenson & Ulloa Ulloa 1994, Brummitt & Lughadha 2003, Barthlott *et al.* 2005), while at the same time the country suffers the highest annual rate (4%) of deforestation in South America (Miller 1998).

The research station "Estación Científica San Francisco" (ECSF; 3°58′ S, 79°04′ W; 1850 m a.s.l., Fig. 3A) is in the valley of the San Francisco River near Sabanilla, between Loja and Zamora. The research area lies within the Eastern Cordillera of the southern Ecuadorian Andes, bordering the Podocarpus National Park. It is situated in the Province of Loja, in the upper part of the San Francisco Valley, below the communication road between Loja and Zamora (Figs. 1, 2A, 3B). An area of about 11 km^2 on the orographically right-hand side of the valley (mostly south of the Estación, with slopes exposed to the north) belongs to the Estación, forming the Reserva Biológica San Francisco (RBSF, 1700–3150 m a.s.l.). It is covered by a tropical mountain rain forest (Figs. 2C, 3C). The highest peak close to the RBSF, the Cerro de Consuelo ("Antenna Peak") reaches to just above the tree line (Figs. 5A, B), which is not very distinct, above the dense and unique *Purdiaea* forest (Fig. 5C). The tree line is relatively low, and is formed by *Polylepis*, *Gynoxis* and some other genera like *Baccharis*, *Buddleja*, *Hesperomeles*, and *Neurolepis*, whose life forms change with increasing altitude from single-stemmed trees to multi-stemmed shrubs.

Recently the area was substantially extended to the opposite side of the valley, where about 20 years ago the forest was cleared for pasture purposes (Fig. 3B) and for *Pinus patula* plantations (Fig. 3B; Breckle *et al.* 2005). Parts of the area in the upper San Francisco valley (El Tiro; Fig. 2B), with the mountain pass to Loja (2800 m) were included in our research, as well as the low pass at Cajanuma (2900 m a.s.l.) south of Loja (Figs. 6A, B, C). In addition, the lower San Francisco Valley near Zamora and Bombuscaro (1200 m a.s.l.) and side-valleys were also often visited. Cajanuma and Bombuscaro are already used for species epithets (e.g., by Illig *et al.*; see Chapter 12).

Mean annual temperatures range from 15.5°C in the lower areas to 9°C at higher elevations. Annual rainfall increases from about 2000 mm in lower areas to more than 5000 mm in higher areas of the RBSF (Emck, University of Erlangen, Germany, unpubl. data; see also the forthcoming volume: Ecolog. Studies 198: Beck *et al.* 2008). The ecological climatic diagrams (Figs. 4A, B) give a general impression. The climatic dynamics and conditions are discussed in more detail by Bendix in Beck *et al.* (2008) and seasonality effects by Bendix *et al.* (2006) and Cueva *et al.* (2006).

Not least because of its ideal location between two manifestations of the local ecosystem, the natural mountain rain forest and its anthropogenic replacement systems, the Estación was chosen for an ecosystem study initiated at the end of 1997. A team of

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FIG. 1. The research area of the Estación Científica San Francisco (ECSF) between Loja and Zamora.

six German research groups started developing the area for research purposes and installing scientific facilities in the station. The group grew over the following years, and in 1999 eleven groups started working. A DFG Research Unit FOR 402: "Functionality in a Tropical Mountain Rainforest: Diversity, Dynamic Processes and Utilization Potentials under Ecosystem Perspectives" was established in 2001, comprising many disciplines in the earth sciences, life sciences, forestry, and social science (see also Beck *et al.* 2008), initially with 17, then 25 and 26 groups. The next phase (FOR 812) started in 2007 with 25 groups and will last until 2010.

When the station was inaugurated in 1997 by its founder, the U.S. foundation "Nature and Culture International", San Diego, with a branch ("Naturaleza y Cultura Internacional") in the provincial capital Loja, the research started with an inventory to identify the essentials of the ecosystems at the organismic (biodiversity) and abiotic levels (soil, climate, landscape history) as the determinants of the high biodiversity of the area and the basis for understanding ecosystem dynamics. This volume presents the results of the biodiversity research in the form of preliminary checklists. It is immediately obvious that no complete overview of such an area can be given in the comparatively short time of nine years, especially as the focus of most projects was not on recording biodiversity but on understanding its underlying causes. For these reasons, major organism groups have to remain unstudied, such as Cyanophyceae, the various algae, most fungi, molluscs, nematodes, Platyhelminthes, annelids, spiders and most mites, and within the insects the large group of the beetles, but also Hymenoptera, flies, etc., to name just the most obvious cases. But even within the checklists presented in this volume, many taxa are still unnamed and can only be listed as the total number of morphospecies in order to give an idea of the overall diversity.

The various processes, the roles and interrelationships of organisms in ecosystems, can only be understood if some of the main functions of the dominant and frequent organism groups are revealed, and if in inventories the taxonomic basis of those dominant groups is available for comparisons between ecosystems. One of the biggest gaps in our knowledge is certainly the nematodes. Seventy percent of the world's metazoan individuals are nematodes. Study of their role in the oceans, in lakes, in soils and sediments of natural forests, and in cultivated as well as afforested sites, where they are the most dominant group (Bongers 1988, Jairajpuri & Ahmad 1992), may reveal the tremendous influence of the nematodes on specific mineralization processes. In terms of species numbers, however, the insects are certainly on top with about one million described species. About 22 000 species of nematodes have been described, but it is estimated that there are 200 000–500 000 species on the globe (Traunspurger, pers. comm.).

The interrelationships of pollinators, where Hymenoptera and Diptera also play a specifically important role, together with the typical tropical pollinators like birds and bats, should be an additional focus in future, as preliminary research shows that the more spectacular, highly specific interrelationships are restricted to a small percentage of plants, while the vast majority are involved in more flexible interactions with several protagonists.

Nevertheless, the results in the groups studied in the vicinity of the "Estación Científica San Francisco" are impressive. It is immediately apparent that organismic diversity is highly variable in different groups. It is extraordinary with respect to vascular (~1400 species identified, Homeier *et al.* 2002, 2004) and non-vascular plants (~800 species identified), to fungi, bats (25 species), birds (~240 species) and some (but not all) groups of insects, e.g., the moths, for which a world record in biodiversity was recorded (~1420 spe-

FIG. 2 A. Old Road between Loja and Zamora, with landslides and forest remnants in ravines west of the Estación Científica (ECSF) in the Reserva Biológica San Francisco (RBSF) (*ca.* 2300 m a.s.l., photo: SWBr 10. 10. 2004).

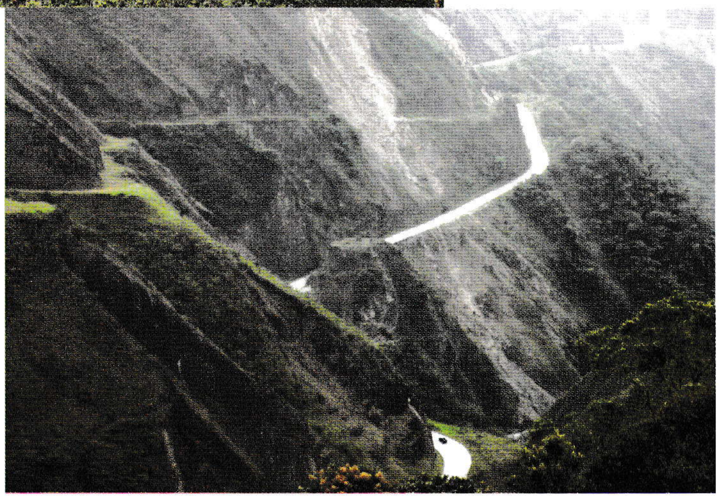

FIG. 2 B. Old and New Road between Loja and Zamora in the upper part of San Francisco valley with huge landslides, view to the east (*ca.* 2200 m a.s.l., photo: SWBr 12. 10. 2004).

FIG. 2 C. View to the north-facing slope of the San Francisco Valley with dense tropical almost primary mountain rain forest opposite the Estación Científica (ECSF), (*ca.* 1900 m a.s.l., photo: SWBr 11. 10. 2004).

FIG. 3 A. Estación Científica (ECSF) in the Reserva Biológica San Francisco (RBSF) (*ca.* 1850 m a.s.l., photo: SWBr 16. 10. 2004).

cies, Brehm *et al.* 2005). On the other hand, diversity in other groups of organisms, like mammals, is low. Therefore "hotspot of biodiversity" does not imply overall high organismic diversity in all taxa.

Summarizing the major factors found responsible for the origin and maintenance of the high biodiversity, the following seem to play a major role, in addition to features of landscape history and fire frequency; for more details see Ecolog. Studies 198: Beck *et al.* (2008).

– The rugged morphology of the area provides an exceptional diversity of slope expositions and inclinations and, as a consequence, outstanding heterogeneity of soils and microsites.

– A shortage of mineral nutrients, which prevents disproportionate dominance by particular tree species (except secondary vegetation).

– The extraordinary frequency of natural landslides (Fig. 3C), favored by tectonic dynamics, a special geology, steep slopes, and a high level of precipitation. These landslides further enhance the already high dynamics of a tropical evergreen forest.

– The perhumid climate as an outcome of the dominating advective easterly air streams, which originate from the trade wind system and give rise to an evergreen tropical mountain forest, followed by a *subpáramo* shrubland (*jalca*) above the gradual timberline (2700–3000 m a.s.l.).

– Biodiversity itself fosters biodiversity, creating niches for other organisms. Trees support lianas and epiphytes as well as a multitude of symbiontic, parasitic, and saprophytic fungi, and the great variety of flowers is associated with insects, birds, and bats (Breckle 2004).

One might argue that biodiversity studies nowadays should also include biomolecular methods of PCR for genome analysis, etc. The results, however, always have to be first compared with classical systematics and taxonomy, otherwise obviously misleading or wrongly interpreted results might often be the consequence, though for specific questions and difficult taxa it might be an appropriate additional tool in future. But especially for fungi (though not only there) it is a very powerful tool (see checklist of mycorrhizal fungi). Certainly classical taxonomy and phylogenies should not be regarded as contradictions, they have to interrelate and to exchange novelties. We need not only analyses, but also good synthesis, which means research at all levels of scale, especially at the ecosystem level, but the preconditions for successful ecological research are always good inventories, not only genetic markers (Breckle 1999, Brehm *et al.* 2008).

The applied aspect of checklists can be seen by the catalogue of useful plants listed according to ethnobotanical criteria.

These checklists are an excellent example of cooperative research. They give new insights into an extremely biodiverse mountainous tropical area and thus

FIG. 3 B. Pastures above the main road on south-facing slopes close to the ECSF, partly used for forestry experimental trials and former *Pinus patula* plantation on the left (*ca.* 1950 m a.s.l., photo: SWBr 12. 10. 2004).

FIG. 3 C. Frequent landslides of various ages on the very steep slopes at the upper RBSF form an extremely large number of different sites and thus a very high geodiversity as an important basis for the high biodiversity (*ca.* 2500 m a.s.l., photo: SWBr 12. 10. 2004).

are an invaluable tool for future comparisons and future chorological studies, even if they in reality can only mark the status quo of the ongoing research.

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Since 2001 the DFG (Deutsche Forschungsgemeinschaft) has funded the research program FOR 402 "Functionality in a Tropical Mountain Rainforest: Diversity, Dynamic Processes and Utilization Potentials under Ecosystem Perspectives", where about 26 groups of researchers were active, as well as the preceding Research Group on "Ecosystematic Characteristics of Disturbed and Undisturbed Tropical Mountain Rainforests" (1997–2001), which succeeded the initial former Research Group on "Mechanisms for Maintaining Tropical Biodiversity" (1993–1997) which was not focused on Ecuador (Dalitz *et al.* 1998). This help, and the steady and strong interest and support shown by Frau Dr. R. Schönwitz of the DFG, is gratefully acknowledged.

The Foundation Nature and Culture International (NCI San Diego and Loja) has made possible the use of the Estación Científica de San Francisco (ECSF) at the northern border of the Podocarpus National Park. The Ecuadorian Ministerio del Ambiente granted the research and collecting permits for the projects. Many local people from the villages, many students and representatives from the universities in Loja, Cuenca, and Quito have helped in various ways. This is greatly appreciated and demonstrates excellent international and interdisciplinary cooperation.

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ABBREVIATIONS IN THE SPECIES LISTS

A number of frequently-used localities and qualifiers are used throughout this volume. Abbreviations only used in one chapter are listed separately in the introduction to the respective chapter.

Locality (2nd column)

- A Estación Científica San Francisco (ECSF)
- B Bombuscaro (Parque Nacional Podocarpus), Rio Bombuscaro entrance, 900–1200 m a.s.l.
- C Cajanuma (Parque Nacional Podocarpus), Cajanuma entrance, 2600–3100 m a.s.l.
- T El Tiro (Parque Nacional Podocarpus), the pass over the eastern range between Loja and Zamora, 2500–2900 m a.s.l.

Vegetation type (ECSF) (4th column)

- I Submontane rain forest (950–1000 m)
- II Montane rain forest (1800–2150 m): *Ocotea-Nectandra* forest
- IIa Devastated montane rain forest, pasture with open vegetation (1900 m)
- III Upper montane rain forest (2150–2650 m): *Myrica andina-Purdiaea nutans* forest
- IV Subalpine dwarf forest and *subpáramo* (2650–3150 m): *jalca* (*ceja andina*) with *Clusia elliptica*; and *subpáramo* (*Neurolepidium* and *Puya*).
- V Upper montane rain forest (cloud forest, Cajanuma, 2750–3000 m)

Frequency (5th column)

- s singleton
- r rare, only a few dispersed specimens found
- + occasional
- ++ regular
- +++ frequent

Chorotypes (6th column)

- **A** Andean (Mexico to Bolivia)
- **A-n** northern Andean (Costa Rica to northern Peru)
- **A-s** southern Andean

Am American

- **Am-C** Central American and /or Caribbean
- **Am-S** South American
- **Am-C, S;** or **Neotrop** Central and South American
- **Am-Afr** American-African

End endemic (Ecuador)

- **End loc** local endemic
- **G** Guayana Highland

- **Pantrop** pantropical (widely tropical, incl. Am-Afr)
- **Subcos** subcosmopolitan
- **Temp** widely temperate.
- **Temp-n** northern temperate
- **Temp-s** southern temperate

Degree of Novelty (7th column)

- **S** = New species
- **nE** = New to Ecuador

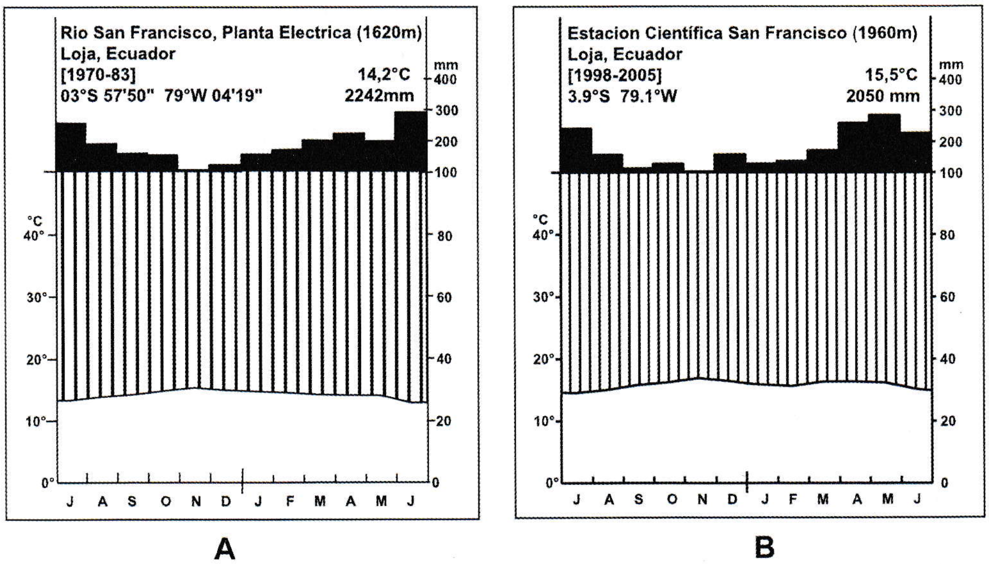

FIG. 4. Ecological climatic diagrams from the Rio San Francisco area, indicating the first period recorded at the former electric power station in the valley bottom, east of ECSF (A, left). Second period recorded at the Research Station (ECSF) itself on the south-facing slope above the river (B, right). (Data from Rollenbeck, with courtesy).

5 A

5 B

5 C

FIG. 5. High mountain sites near RBSF (all photographs by Jürgen Homeier). A upper: close below the Cerro de Consuelo ("antenna peak"), 3100 m a.s.l. B middle: view from the Cerro de Consuelo, 3150 m a.s.l.
C lower: *Purdiaea* forest, about 2500 m a.s.l., at transect 1.

6 A

6 B

6 C

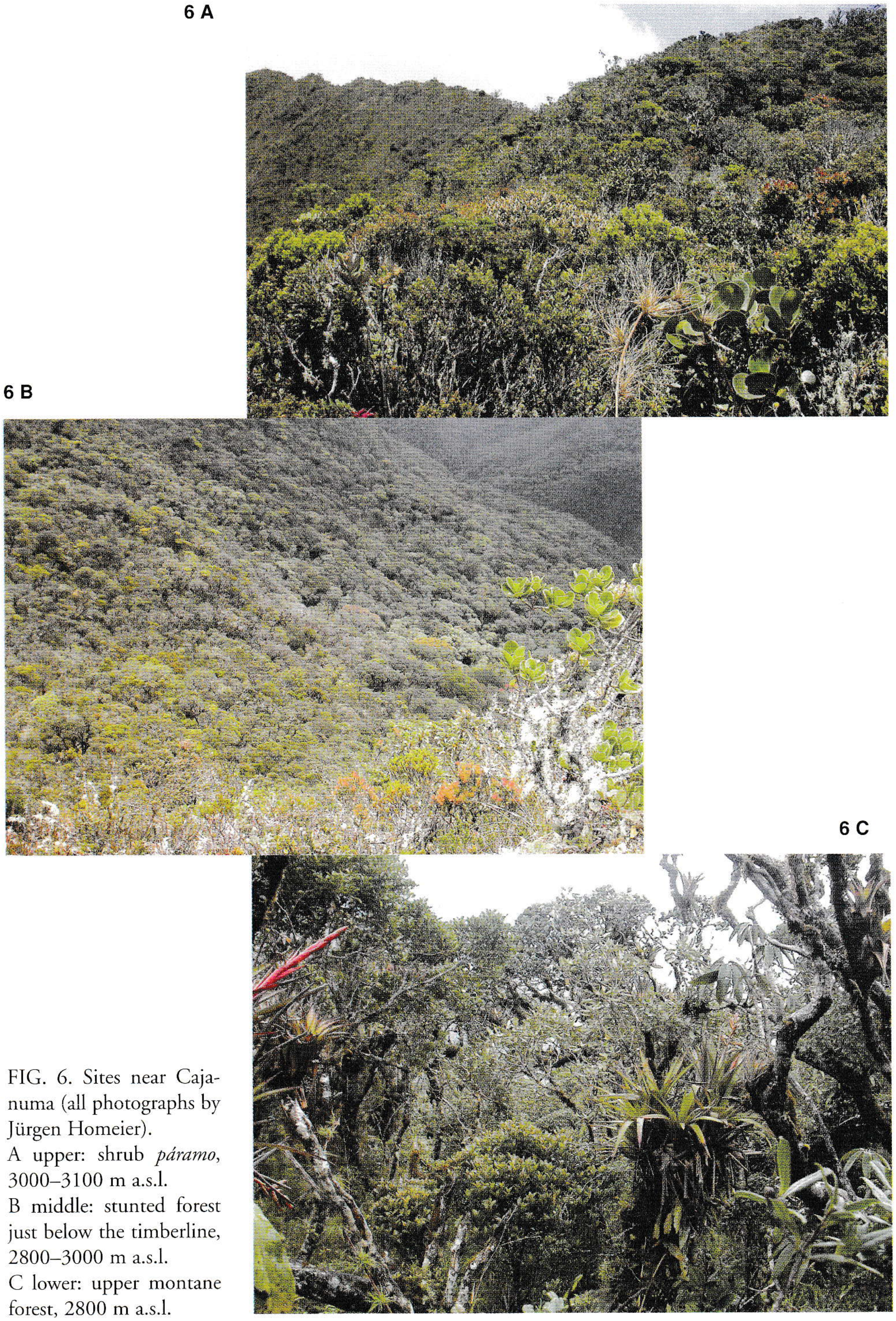

FIG. 6. Sites near Cajanuma (all photographs by Jürgen Homeier).
A upper: shrub *páramo*, 3000–3100 m a.s.l.
B middle: stunted forest just below the timberline, 2800–3000 m a.s.l.
C lower: upper montane forest, 2800 m a.s.l.