

Natural and Cultural History of the Golfo Dulce Region, Costa Rica

Anton WEISSENHOFER, Werner HUBER,
Veronika MAYER, Susanne PAMPERL, Anton WEBER,
Gerhard AUBRECHT (scientific editors)

HPSG.: Biologiezentrum der Oberösterreichischen Landesmuseen



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Historia natural y cultural de la
región del Golfo Dulce, Costa Rica

Anton WEISSENHOFER, Werner HUBER, Veronika MAYER, Susanne PAMPERL,
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The climate of the Esquinas rainforest¹

El clima del bosque lluvioso Esquinas

Anton WEISSENHOFER & Werner HUBER

Abstract: A brief survey is given of the climatic situation of the Esquinas rainforest (Piedras Blancas National Park), based on precipitation, temperature and other meteorological data gathered between 1999 and 2007 at the “Tropenstation La Gamba”. With an annual precipitation of c. 5.836 mm, the Esquinas forest belongs to the wettest lowland forests in Costa Rica and in the whole of Central America. Rainfall is not evenly distributed throughout the year. There is a decline from January to March (although not usually causing a water deficit), and a second, shorter and less pronounced decline in July and/or August (“veranillo”). Rainfall is highest in September and October. Temperatures are more uniform throughout the year (average 28.2°C). Nonetheless, there may occur much variation, particularly as to rainfall and as to the effect of El Niño.

Key words: Costa Rica, Esquinas forest, Piedras Blancas National Park, climate, precipitation, temperature, humidity, wind, storms, El Niño.

Resumen: Se da a conocer una breve investigación sobre la situación climática del bosque lluvioso Esquinas (Parque Nacional Piedras Blancas), basada en la precipitación, temperatura y otros datos meteorológicos obtenidos entre 1999 y 2007 en la “Estación Tropical la Gamba”. Con una precipitación anual de 5,836 mm, el bosque Esquinas pertenece a los bosques lluviosos en Costa Rica y América Central, respectivamente. La lluvia no es constante durante todo el año. Hay una declinación de Enero a Marzo (que usualmente no produce un déficit de agua), y una segunda declinación, mas breve y no tan pronunciada, en Julio y/o Agosto (“veranillo”). La lluvia es abundante en Septiembre y Octubre. La temperatura es uniforme a través del año (promedio 28,2°C). No obstante, puede existir mucha variación, en particular en lo referido a las precipitaciones y al efecto de El Niño.

Palabras clave: Costa Rica, bosque Esquinas, Parque Nacional Piedras Blancas, clima, precipitación, temperatura, humedad, viento, tormentas, El Niño.

Introduction

The climate is the most important factor shaping the vegetation in a given area. The present paper deals briefly with the climatic situation of the Esquinas rainforest (Piedras Blancas National Park), based on data collected at the “Tropenstation La Gamba” (La Gamba Field Station). Apart from rainfall (precipitation) and temperature, other factors such as humidity, storms and special conditions (El Niño) are addressed.

Rainfall

The Esquinas forest (Piedras Blancas National Park) is one of the wettest lowland forests in Costa Rica and in the whole of Central America. This is due to the rain gradient caused by the mountains of the Fila Cruces range. Generally, on the Pacific side of Central America there are distinct rainy (May to November)

and dry (December to April) seasons, with heaviest rainfalls occurring in October and November. On the Central American isthmus, and particularly in Costa Rica, this pattern is modified to a considerable degree by the presence and orientation of the mountain ranges. During the months with the highest precipitation (August to November), rainfall occurs on almost every day. Typically, the rainfall is in the afternoon and during the night, in short, heavy showers. In September and October, it may even rain for periods of up to 24 hours. The driest months are January, February and March and during that time there may be no rainfall for several consecutive days. Another short drier period (approximately three weeks) may occur in July and/or August. This is called the “veranillo” (“little summer”).

Meteorological data have been recorded since 1998 at the Tropenstation La Gamba and complete data sets for precipitation and temperatures are available for the years 1999 to 2007 (Tab. 1, Fig. 1). During that period, the average annual precipitation was 5.836 mm. The

¹ Updated and modified version of WEISSENHOFER & HUBER 2001.

Tab. 1: Rainfall (mm) during 1999 to 2007 at the Tropenstation La Gamba.

| Tropenstation La Gamba | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | Average |
|-------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|----------------|
| January | 397 | 294 | 307 | 179 | 243 | 196 | 131 | 209 | 161 | 235 |
| February | 321 | 77 | 210 | 185 | 192 | 72 | 364 | 78 | 163 | 185 |
| March | 273 | 233 | 176 | 192 | 128 | 408 | 388 | 316 | 169 | 254 |
| April | 507 | 374 | 220 | 265 | 227 | 334 | 503 | 374 | 425 | 359 |
| May | 397 | 486 | 622 | 340 | 526 | 931 | 495 | 548 | 1000 | 594 |
| June | 566 | 612 | 498 | 477 | 497 | 433 | 572 | 459 | 512 | 514 |
| July | 470 | 473 | 584 | 643 | 714 | 508 | 592 | 540 | 502 | 558 |
| August | 742 | 683 | 499 | 389 | 554 | 730 | 588 | 416 | 766 | 596 |
| September | 998 | 1209 | 710 | 946 | 456 | 709 | 700 | 556 | 716 | 778 |
| October | 633 | 741 | 781 | 750 | 869 | 828 | 664 | 839 | 909 | 779 |
| November | 684 | 641 | 926 | 411 | 612 | 366 | 797 | 580 | 767 | 642 |
| December | 410 | 250 | 477 | 473 | 274 | 148 | 217 | 331 | 516 | 344 |
| Total | 6398 | 6072 | 6008 | 5247 | 5290 | 5658 | 6008 | 5243 | 6602 | 5836 |

Tab. 2: Climatic data for the Tropenstation La Gamba.

| | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 |
|--|--------------------|-------------------|-------------------|-------------------|-------------------|------------------|-------------------|-------------------|------------------|
| Total annual precipitation each year in mm | 6398 | 6072 | 6008 | 5247 | 5290 | 5658 | 6008 | 5243 | 6602 |
| Max. daily precipitation in mm. | 133 (25. Sept.) | 152 (3. Sept.) | 117 (31. Oct.) | 135 (13. Nov.) | 123 (29. Oct.) | 224 (18. May) | 160 (25. Oct.) | 150 (15. Oct.) | 157 (24. May) |
| No. of days without rain | 63 | 93 | 89 | 86 | 101 | 120 | 73 | 101 | 80 |
| No. of days with rain | 302 | 273 | 276 | 279 | 264 | 246 | 292 | 264 | 285 |

Tab. 3: Mean monthly minimum, maximum and average air temperatures (in °C) at the Tropenstation La Gamba, 1999-2007.

| Month | Mean monthly minimum | Mean monthly maximum | Mean monthly average |
|--------------|-----------------------------|-----------------------------|-----------------------------|
| January | 23.1 | 32.6 | 27.9 |
| February | 23.3 | 33.0 | 28.4 |
| March | 24.0 | 34.1 | 29.1 |
| April | 24.2 | 34.0 | 29.1 |
| May | 24.2 | 33.3 | 28.8 |
| June | 23.8 | 32.8 | 28.3 |
| July | 23.7 | 32.5 | 28.1 |
| August | 23.7 | 32.5 | 28.1 |
| September | 23.7 | 32.8 | 28.3 |
| October | 23.6 | 31.8 | 27.7 |
| November | 23.5 | 31.3 | 27.4 |
| December | 23.3 | 31.2 | 27.3 |

highest monthly average was in October (770 mm) and September (778 mm). In May 2004, 224 mm (that is c. 4% of the annual precipitation) of precipitation were measured in a day. The driest months were January (235 mm), February (185 mm) and March (254 mm). Variation was highest in February, with precipitation values ranging from 77 mm (2000) to 364 mm (2005). However, the period between January and March cannot be qualified as a dry season (no water deficit) and nor is it comparable with dry seasons in other areas of Costa Rica. In the “veranillo”, the monthly precipitation is not

much lower than in the adjacent months (July 1999: 470 mm were measured, Aug. 2002: 389 mm).

The rainfall on the coast of the Esquinas forest, measured by Ron and Trude McAllister (Casa Orquideas) from 1985 to 1999, and at the Ranger station in the Valle Bonito in the centre of the Esquinas forest (measured by MINAE staff in 2002 and 2003), show similar values (Fig. 2 and 3) to those recorded at the Tropenstation.

Rainy days per year. Between 1999 and 2007, at the Tropenstation, the number of rainy days ranged from 246 and 302 days per year, that is from 2/3 to 4/5 of the days of the year. In that period, the average number of rainy days was 276 per year (3/4, In 2000, over 60% of the annual precipitation fell on just 67 days. There was no rain on 93 days (Tab. 2) and less than 10 mm of rain was recorded on 104 days.

Effects of drought. During the drier period (January-March), some trees may drop their leaves completely and a considerable quantity of leaf litter accumulates on the forest floor. Some of the smaller streams on steep terrain dry up, but others persist and form small pockets of water. From December 1997 to April 1998, “El Niño” had a great effect on the region and little rain fell during this period. Many epiphytes died, but others recovered within a few months.

Temperature

Because Costa Rica is located in the equatorial zone, the average temperature of the warmest month does not exceed the average temperature of the coolest month by more than 2°C. Temperature measurements at Tropenstation La Gamba have been made sporadically since December 1993 and regularly since January 1999 until 2007 (Tab. 2). The average yearly temperature was 28.2°C.

The months with the highest average temperatures were found to be April and May, with 29.1°C. The absolute maximum temperature measured was 39°C (December 2001). The coolest month was December, with an average temperature of 27.3°C (Tab. 3). An absolute minimum (night) temperature of 20°C was reached in August 1998.

Diurnal temperature variation. The drier season usually shows a greater amplitude of diurnal temperatures (based on monthly averages) than the rainy season. A wide range, between 10°C and 13°C, was recorded during the months January, February and March and sometimes also in April and May. The highest variation during a day (up to 15°C) occurred in September and December. The least diurnal variation was around 2°C and occurred during long rainy periods in October and November. At that time there were clouds throughout the day and night.

The seasonal variation in the mean monthly average at the field station was about 2°C, and thus the diurnal temperature variation was greater than the seasonal temperature variation.

Humidity

Relative humidity is equally high throughout the year (averaging 88.3% at the station, minimum c. 80%). It is considerably higher within the forest (97.7%) (ASHAN 1996). Mist forms daily at dawn and sometimes at dusk and after heavier rainfalls. Under misty conditions, the air temperature is lower.

Wind and storms

Generally, winds and storms are of low importance in the region. They do occur, but rarely with the force of a tornado (COEN 1983, BOZA & MENDOZA 1981). However storms may play a destructive rôle on the high peaks (e.g., Nicuesa). In May 1997, an exceptionally strong storm severely affected La Gamba and its vicinity. In the forest, mainly on steep ridges, many large trees were felled and large gaps were created.

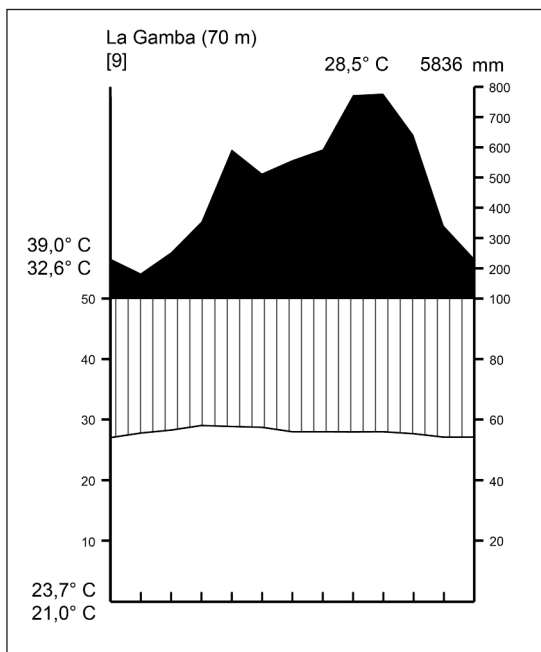


Fig. 1: Climate diagram, Tropenstation La Gamba (70 m above sea level).

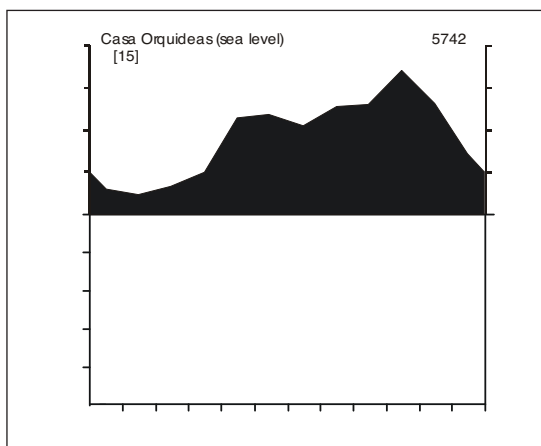


Fig. 2: Precipitation diagram, Casa Orquideas (sea level).

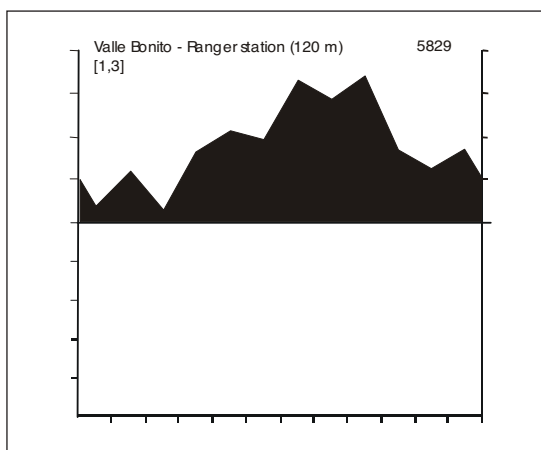


Fig. 3: Precipitation diagram, Ranger Station in the Valle Bonito (140 m above sea level).

Conclusions

The climatic situation in the Esquinas rainforest can be well characterised: while the temperatures are fairly even throughout the year, precipitation follows a clearly seasonal pattern. Nonetheless, the meteorological data gathered at the Tropenstation from 1999 to 2007, show that there is considerable variation from year to year and that El Niño years produce special effects that could even threaten the survival of particular plant species (especially epiphytic species).

References

- ASCHAN G. (1996): Mikroklima von Sekundär- und Primärregewälder der pazifischen Tieflandregion Costa Ricas. Ergebnisse einer Meßkampagne vom März/April 1995. — Düsseldorf: unpubl. Thesis on Univ. Heinrich-Heine.
- BOZA M.A. & R. MENDOZA (1981): Costa Rica national parks. — Madrid: Incafo.
- COEN E. (1983): Climate. — In: JANZEN D.H. (ed.), Costa Rican natural history. Chicago: Univ. of Chicago Press: 35-46.
- WEISSENHOFER A. & W. HUBER (2001): Basic Geographical and Climatic Features of the Golfo Dulce Region. — *Stapfia* **78**: 11-14.

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