

# A BIBLIOGRAPHY OF BIOLOGICAL LITERATURE ON EPIPHYTES: AN UPDATE

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**ABSTRACT.** A bibliographic list of 571 citations dealing with the biology of vascular and non-vascular epiphytes that updates the list compiled by Watson *et al.* (1987) is provided. Papers pertinent to the ecology, biochemistry, physiology, anatomy, horticulture, morphology, and natural history of epiphytes from tropical, temperate, and boreal regions are included. Purely taxonomic and floristic accounts are generally excluded. The bibliography is also available in electronic form.

Una bibliografía reciente de temas biológicos sobre epífitas.

**RESUMEN.** Con el propósito de actualizar la contribución de Watson *et al.* (1987), se presenta una lista de 571 citas bibliográficas relacionadas con la biología de plantas epífitas vasculares y no vasculares. Se incluyen artículos relacionados con la ecología, bioquímica, fisiología, anatomía, horticultura, morfología, e historia natural de epífitas de regiones boreales, templadas y tropicales. Contribuciones puramente taxonómicas y florísticas fueron usualmente excluidas. Esta bibliografía es también disponible en forma electrónica.

## INTRODUCTION

This bibliography of scientific and horticultural literature about vascular and non-vascular epiphytes is intended as an addendum to a similar bibliography published in *Selbyana* five years ago (Watson *et al.*, 1987). This earlier publication has proven to be a valuable reference for biologists and one that should be maintained with the addition of pertinent citations. Interest generated at the Second International Symposium on the Biology and Conservation of Epiphytes held 5-9 May 1991 at The Marie Selby Botanical Gardens, further demonstrated the need for an updated bibliography of the current literature. The Symposium was a gathering of scientists, horticulturists, and conservationists with widely diverse interests. A goal of this bibliographic project is to reflect that diversity.

In contrast to the original list, this bibliography includes citations related to non-vascular as well as vascular epiphytes. This inclusion reflects the growing interest in these plants, especially in the fields of ecosystem ecology and air-quality monitoring. We also expanded the geographic scope from the tropical emphasis of the original list to include temperate and boreal regions. General subjects included are: evolution, biochemistry, phytosociology, and other areas of biological study (APPENDIX 1). Purely taxonomic and systematic works such as monographs of particular taxa are excluded in this list, as those references are accessible through other sources such as the Kew Index.

The scope of this list was also broadened to include research on the conservation and prop-

agation of epiphytes. Because habitats of epiphytes are facing increasing threats from human activities, these subjects necessarily come to the forefront of epiphyte study. One of the conclusions of the Symposium was that conservation activities must be rooted in sound scientific knowledge of the natural history of the plants and habitats to be conserved; this bibliography may serve as one step in that process.

The citations presented here were collected by a thorough search of relevant publications available to the authors. These included journals, proceedings, books, and unpublished dissertations. Some appropriate citations may have been overlooked, and we request that omissions and corrections be sent to the Director of Research at Selby Gardens for inclusion in the next update.

Most of the citations were verified for correctness either directly from the original publication or reprint or from Biological Abstracts. We could not verify some citations, and those are identified with an asterisk. The citations are listed alphabetically and chronologically by author, followed by year, title, and reference. Each citation was keyworded by the second author to summarize the general subject matter (APPENDIX 1), the type of plant studied (APPENDIX 2), and the geographical region in which the study took place (APPENDIX 3).

This list and the previous list are available on diskette with keywords to facilitate searching and sorting. The lists are available in three forms: a) hardcopy (reprint); b) as unformatted ASCII form; and c) a bibliographic database (PROCITE: Personal Bibliographic Software, Inc., Ann Arbor, Michigan, U.S.A.). Interested persons should

contact the Research Librarian, Selby Gardens, to receive this bibliography.

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## APPENDIX 1. Bibliographic citations sorted by subject.

|                              |     |     |     |     |     |     |     |     |     |
|------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| <b>Anatomy</b>               |     |     |     |     |     |     |     |     |     |
| 39                           | 79  | 168 | 183 | 264 | 394 | 411 | 472 | 536 |     |
| 69                           | 99  | 171 | 224 | 350 | 399 | 412 | 478 | 566 |     |
| 70                           | 114 | 181 | 241 | 374 | 408 | 413 | 534 |     |     |
| <b>Applications</b>          |     |     |     |     |     |     |     |     |     |
| 3                            | 83  | 128 | 232 | 260 | 314 | 382 | 473 | 520 | 562 |
| 11                           | 89  | 135 | 243 | 267 | 328 | 385 | 493 | 537 |     |
| 23                           | 91  | 137 | 244 | 285 | 337 | 386 | 494 | 541 |     |
| 37                           | 109 | 142 | 247 | 290 | 347 | 392 | 498 | 542 |     |
| 46                           | 110 | 143 | 249 | 291 | 349 | 430 | 499 | 543 |     |
| 49                           | 112 | 185 | 251 | 304 | 357 | 438 | 501 | 544 |     |
| 50                           | 116 | 203 | 252 | 305 | 364 | 447 | 507 | 548 |     |
| 59                           | 119 | 213 | 253 | 306 | 373 | 463 | 514 | 560 |     |
| 78                           | 121 | 215 | 254 | 313 | 377 | 464 | 516 | 561 |     |
| <b>Bibliography</b>          |     |     |     |     |     |     |     |     |     |
| 251                          | 252 | 253 | 254 | 280 | 545 |     |     |     |     |
| <b>Biochemistry</b>          |     |     |     |     |     |     |     |     |     |
| 25                           | 149 | 237 | 261 | 353 | 479 | 551 |     |     |     |
| 30                           | 184 | 238 | 262 | 365 | 488 | 552 |     |     |     |
| 47                           | 224 | 239 | 263 | 399 | 489 |     |     |     |     |
| 103                          | 228 | 240 | 308 | 406 | 504 |     |     |     |     |
| 124                          | 235 | 242 | 319 | 467 | 505 |     |     |     |     |
| 126                          | 236 | 257 | 329 | 469 | 550 |     |     |     |     |
| <b>Biography and History</b> |     |     |     |     |     |     |     |     |     |
| 27                           | 121 | 203 | 307 | 330 |     |     |     |     |     |
| <b>Conservation Biology</b>  |     |     |     |     |     |     |     |     |     |
| 3                            | 44  | 200 | 273 | 334 | 556 |     |     |     |     |
| 23                           | 174 | 234 | 277 | 487 |     |     |     |     |     |
| <b>Cytology</b>              |     |     |     |     |     |     |     |     |     |
| 15                           | 99  | 125 | 170 | 283 | 383 | 462 | 489 | 536 |     |
| 38                           | 114 | 126 | 181 | 323 | 411 | 470 | 512 | 558 |     |
| 79                           | 124 | 168 | 183 | 345 | 413 | 478 | 528 | 564 |     |
| <b>Ecology</b>               |     |     |     |     |     |     |     |     |     |
| 1                            | 41  | 68  | 94  | 139 | 165 | 195 | 496 | 523 | 570 |
| 2                            | 47  | 69  | 95  | 140 | 172 | 196 | 497 | 524 | 571 |
| 3                            | 48  | 71  | 100 | 141 | 173 | 197 | 501 | 525 |     |
| 4                            | 51  | 72  | 101 | 144 | 176 | 200 | 502 | 526 |     |
| 6                            | 52  | 73  | 103 | 145 | 177 | 202 | 503 | 531 |     |
| 7                            | 55  | 74  | 108 | 146 | 182 | 204 | 508 | 532 |     |
| 9                            | 57  | 75  | 111 | 147 | 185 | 205 | 510 | 533 |     |
| 12                           | 58  | 76  | 113 | 148 | 186 | 206 | 512 | 534 |     |
| 13                           | 59  | 77  | 115 | 149 | 187 | 207 | 513 | 535 |     |
| 14                           | 60  | 81  | 120 | 150 | 188 | 208 | 514 | 538 |     |
| 16                           | 61  | 82  | 123 | 151 | 189 | 209 | 517 | 546 |     |
| 17                           | 62  | 86  | 129 | 153 | 190 | 211 | 518 | 547 |     |
| 19                           | 63  | 87  | 131 | 156 | 191 | 212 | 519 | 553 |     |
| 20                           | 64  | 88  | 132 | 157 | 192 | 219 | 520 | 557 |     |
| 35                           | 65  | 90  | 133 | 158 | 193 | 220 | 521 | 567 |     |
| 40                           | 66  | 93  | 138 | 159 | 194 | 223 | 522 | 569 |     |
| <b>Economic Botany</b>       |     |     |     |     |     |     |     |     |     |
| 109                          | 121 | 214 | 542 | 543 | 544 |     |     |     |     |
| <b>Evolutionary Biology</b>  |     |     |     |     |     |     |     |     |     |
| 8                            | 69  | 107 | 150 | 167 | 211 | 339 | 411 | 470 |     |
| 47                           | 72  | 108 | 161 | 173 | 219 | 346 | 441 | 483 |     |
| 64                           | 87  | 125 | 162 | 201 | 224 | 370 | 442 | 484 |     |
| 65                           | 101 | 129 | 163 | 207 | 230 | 371 | 443 | 512 |     |
| 66                           | 106 | 145 | 164 | 208 | 274 | 372 | 452 | 567 |     |

## APPENDIX 1. Continued.

|                                |     |     |     |     |     |     |     |     |     |  |
|--------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|--|
| <b>Genetics</b>                |     |     |     |     |     |     |     |     |     |  |
| 8                              | 38  | 84  | 105 | 298 | 310 | 450 | 476 | 484 | 500 |  |
| 15                             | 39  | 104 | 108 | 299 | 343 | 452 | 483 | 486 |     |  |
| <b>Herbaria</b>                |     |     |     |     |     |     |     |     |     |  |
| 245                            |     |     |     |     |     |     |     |     |     |  |
| <b>Invertebrates</b>           |     |     |     |     |     |     |     |     |     |  |
| 1                              | 47  | 129 | 150 | 194 | 274 | 315 | 396 | 466 | 547 |  |
| 2                              | 57  | 131 | 151 | 195 | 276 | 316 | 431 | 467 | 553 |  |
| 4                              | 64  | 132 | 156 | 196 | 277 | 327 | 432 | 482 | 569 |  |
| 9                              | 77  | 133 | 180 | 197 | 278 | 358 | 433 | 512 | 570 |  |
| 16                             | 81  | 138 | 186 | 206 | 282 | 372 | 434 | 517 |     |  |
| 17                             | 100 | 147 | 187 | 269 | 300 | 390 | 445 | 519 |     |  |
| 20                             | 116 | 148 | 188 | 271 | 303 | 391 | 455 | 538 |     |  |
| <b>Mineral Nutrition</b>       |     |     |     |     |     |     |     |     |     |  |
| 24                             | 76  | 258 | 359 | 393 | 417 | 531 |     |     |     |  |
| 63                             | 198 | 259 | 360 | 403 | 432 | 534 |     |     |     |  |
| 66                             | 226 | 312 | 361 | 406 | 525 | 568 |     |     |     |  |
| 69                             | 227 | 355 | 378 | 415 | 530 |     |     |     |     |  |
| <b>Morphology</b>              |     |     |     |     |     |     |     |     |     |  |
| 8                              | 85  | 115 | 167 | 264 | 350 | 424 | 448 |     |     |  |
| 22                             | 92  | 117 | 199 | 272 | 384 | 425 | 451 |     |     |  |
| 29                             | 106 | 134 | 206 | 324 | 414 | 426 | 506 |     |     |  |
| 79                             | 107 | 154 | 224 | 326 | 423 | 427 | 527 |     |     |  |
| <b>Ornamental Horticulture</b> |     |     |     |     |     |     |     |     |     |  |
| 54                             | 89  | 142 | 233 | 511 | 561 |     |     |     |     |  |
| 78                             | 109 | 210 | 330 | 560 | 562 |     |     |     |     |  |
| <b>Pathology</b>               |     |     |     |     |     |     |     |     |     |  |
| 325                            | 369 | 377 | 546 |     |     |     |     |     |     |  |
| <b>Physiology</b>              |     |     |     |     |     |     |     |     |     |  |
| 12                             | 65  | 119 | 192 | 257 | 325 | 348 | 395 | 457 | 534 |  |
| 24                             | 66  | 140 | 198 | 258 | 331 | 359 | 406 | 459 | 536 |  |
| 42                             | 69  | 141 | 229 | 261 | 332 | 360 | 416 | 471 | 537 |  |
| 43                             | 70  | 144 | 230 | 263 | 333 | 374 | 417 | 473 | 559 |  |
| 56                             | 97  | 169 | 231 | 268 | 339 | 378 | 446 | 490 | 565 |  |
| 61                             | 101 | 175 | 233 | 269 | 340 | 379 | 448 | 493 | 568 |  |
| 62                             | 117 | 176 | 247 | 292 | 341 | 380 | 453 | 508 | 571 |  |
| 63                             | 118 | 179 | 256 | 308 | 342 | 383 | 456 | 509 |     |  |
| <b>Phytosociology</b>          |     |     |     |     |     |     |     |     |     |  |
| 13                             | 60  | 94  | 189 | 218 | 297 | 418 | 513 |     |     |  |
| 14                             | 72  | 111 | 204 | 219 | 301 | 440 | 520 |     |     |  |
| 51                             | 74  | 120 | 207 | 220 | 344 | 458 | 522 |     |     |  |
| 54                             | 82  | 123 | 208 | 221 | 354 | 468 | 523 |     |     |  |
| 55                             | 87  | 172 | 209 | 225 | 387 | 471 | 524 |     |     |  |
| 58                             | 93  | 182 | 212 | 288 | 405 | 502 | 557 |     |     |  |
| <b>Systematics</b>             |     |     |     |     |     |     |     |     |     |  |
| 19                             | 48  | 92  | 160 | 178 | 237 | 270 | 345 | 465 | 528 |  |
| 22                             | 54  | 102 | 161 | 199 | 238 | 271 | 371 | 470 | 535 |  |
| 25                             | 56  | 105 | 162 | 200 | 239 | 272 | 402 | 471 | 549 |  |
| 38                             | 69  | 108 | 163 | 224 | 240 | 297 | 408 | 512 | 563 |  |
| 39                             | 73  | 121 | 164 | 235 | 242 | 301 | 440 | 513 |     |  |
| 41                             | 85  | 125 | 167 | 236 | 248 | 317 | 454 | 517 |     |  |
| <b>Tissue Culture</b>          |     |     |     |     |     |     |     |     |     |  |
| 53                             | 110 | 233 | 313 | 349 | 541 |     |     |     |     |  |
| 83                             | 232 | 260 | 314 | 447 | 562 |     |     |     |     |  |

## APPENDIX 2. Bibliographic citations sorted by taxonomic categories.

|                    |     |     |     |     |     |     |     |     |     |
|--------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Bromeliaceae       |     |     |     |     |     |     |     |     |     |
| 16                 | 78  | 91  | 175 | 202 | 299 | 332 | 365 | 437 | 511 |
| 37                 | 79  | 112 | 181 | 204 | 303 | 333 | 376 | 463 | 527 |
| 58                 | 80  | 139 | 194 | 220 | 316 | 339 | 378 | 469 | 528 |
| 59                 | 84  | 142 | 195 | 229 | 320 | 341 | 390 | 481 | 543 |
| 60                 | 85  | 143 | 196 | 231 | 327 | 352 | 391 | 494 |     |
| 69                 | 89  | 153 | 197 | 298 | 331 | 360 | 393 | 497 |     |
| Gesneriaceae       |     |     |     |     |     |     |     |     |     |
| 53                 | 199 | 340 | 350 | 476 |     |     |     |     |     |
| Lichens            |     |     |     |     |     |     |     |     |     |
| 19                 | 123 | 200 | 239 | 252 | 285 | 328 | 397 | 454 | 534 |
| 49                 | 130 | 205 | 240 | 253 | 301 | 337 | 400 | 460 | 537 |
| 50                 | 135 | 213 | 241 | 254 | 302 | 364 | 403 | 473 | 546 |
| 76                 | 137 | 235 | 242 | 265 | 305 | 373 | 405 | 475 | 548 |
| 82                 | 182 | 236 | 243 | 266 | 306 | 382 | 430 | 498 | 557 |
| 116                | 184 | 237 | 249 | 267 | 309 | 384 | 438 | 516 |     |
| 122                | 185 | 238 | 251 | 284 | 323 | 388 | 448 | 520 |     |
| Nonvascular plants |     |     |     |     |     |     |     |     |     |
| 14                 | 82  | 173 | 218 | 296 | 366 | 404 | 436 | 491 | 532 |
| 35                 | 88  | 189 | 219 | 301 | 369 | 405 | 438 | 495 | 557 |
| 51                 | 113 | 190 | 220 | 311 | 375 | 407 | 441 | 496 | 563 |
| 55                 | 120 | 191 | 221 | 323 | 381 | 409 | 454 | 501 |     |
| 61                 | 122 | 192 | 222 | 324 | 385 | 415 | 460 | 522 |     |
| 62                 | 123 | 193 | 250 | 338 | 392 | 420 | 470 | 523 |     |
| 71                 | 140 | 198 | 265 | 355 | 398 | 421 | 477 | 524 |     |
| 74                 | 144 | 205 | 266 | 364 | 401 | 435 | 480 | 525 |     |
| Orchidaceae        |     |     |     |     |     |     |     |     |     |
| 1                  | 31  | 98  | 138 | 170 | 257 | 314 | 408 | 458 | 550 |
| 2                  | 32  | 100 | 145 | 171 | 258 | 317 | 411 | 462 | 551 |
| 3                  | 33  | 101 | 146 | 172 | 259 | 319 | 412 | 464 | 552 |
| 4                  | 34  | 102 | 147 | 174 | 260 | 325 | 413 | 465 | 554 |
| 5                  | 35  | 103 | 148 | 179 | 261 | 326 | 417 | 472 | 555 |
| 6                  | 36  | 104 | 149 | 187 | 262 | 329 | 420 | 478 | 556 |
| 7                  | 38  | 105 | 150 | 188 | 263 | 330 | 421 | 479 | 558 |
| 8                  | 39  | 106 | 151 | 201 | 269 | 334 | 422 | 487 | 559 |
| 9                  | 41  | 107 | 152 | 203 | 270 | 335 | 423 | 488 | 560 |
| 10                 | 42  | 108 | 154 | 210 | 271 | 336 | 428 | 489 | 561 |
| 11                 | 43  | 109 | 155 | 211 | 273 | 343 | 431 | 492 | 562 |
| 12                 | 44  | 110 | 156 | 214 | 276 | 344 | 432 | 493 | 564 |
| 15                 | 45  | 113 | 157 | 215 | 278 | 347 | 433 | 499 | 565 |
| 17                 | 46  | 114 | 158 | 217 | 279 | 349 | 434 | 500 | 566 |
| 18                 | 48  | 115 | 159 | 225 | 280 | 353 | 439 | 504 | 567 |
| 20                 | 52  | 117 | 160 | 226 | 283 | 369 | 440 | 505 | 568 |
| 21                 | 54  | 118 | 161 | 228 | 290 | 370 | 442 | 507 | 569 |
| 22                 | 70  | 119 | 162 | 231 | 291 | 377 | 443 | 518 | 570 |
| 23                 | 73  | 121 | 163 | 232 | 292 | 379 | 444 | 519 | 571 |
| 25                 | 77  | 124 | 164 | 233 | 294 | 380 | 445 | 529 |     |
| 26                 | 81  | 125 | 165 | 234 | 295 | 383 | 446 | 536 |     |
| 27                 | 83  | 126 | 166 | 246 | 300 | 387 | 447 | 539 |     |
| 28                 | 90  | 127 | 167 | 247 | 304 | 394 | 449 | 541 |     |
| 29                 | 94  | 128 | 168 | 248 | 310 | 399 | 452 | 542 |     |
| 30                 | 97  | 131 | 169 | 256 | 313 | 402 | 455 | 549 |     |
| Piperaceae         |     |     |     |     |     |     |     |     |     |
| 450                | 451 | 515 |     |     |     |     |     |     |     |
| Pteridophyta       |     |     |     |     |     |     |     |     |     |
| 47                 | 144 | 264 | 371 | 471 | 485 | 513 |     |     |     |
| 56                 | 183 | 272 | 396 | 483 | 486 | 538 |     |     |     |
| 99                 | 206 | 289 | 453 | 484 | 512 | 544 |     |     |     |

## APPENDIX 2. Continued.

|                    |     |     |     |     |     |     |     |     |  |
|--------------------|-----|-----|-----|-----|-----|-----|-----|-----|--|
| Other Plant Family |     |     |     |     |     |     |     |     |  |
| 63                 | 178 | 282 | 345 | 367 | 414 | 426 | 457 | 510 |  |
| 92                 | 224 | 307 | 346 | 374 | 415 | 427 | 459 | 536 |  |
| 134                | 245 | 309 | 351 | 395 | 424 | 428 | 506 |     |  |
| 136                | 268 | 318 | 359 | 406 | 425 | 456 | 509 |     |  |

## APPENDIX 3. Bibliographic citations sorted by location of study.

|                           |     |     |     |     |     |     |     |     |     |
|---------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Boreal                    |     |     |     |     |     |     |     |     |     |
| 241                       |     |     |     |     |     |     |     |     |     |
| Florida                   |     |     |     |     |     |     |     |     |     |
| 10                        | 58  | 195 | 204 | 299 | 332 | 345 |     |     |     |
| 11                        | 60  | 196 | 217 | 317 | 335 | 469 |     |     |     |
| 44                        | 70  | 197 | 298 | 331 | 336 | 490 |     |     |     |
| General                   |     |     |     |     |     |     |     |     |     |
| 3                         | 65  | 129 | 161 | 211 | 283 | 335 | 407 | 465 | 519 |
| 8                         | 66  | 130 | 162 | 222 | 285 | 336 | 408 | 472 | 534 |
| 15                        | 68  | 131 | 163 | 224 | 286 | 343 | 411 | 474 | 536 |
| 20                        | 73  | 133 | 164 | 230 | 297 | 351 | 420 | 475 | 540 |
| 21                        | 74  | 135 | 166 | 251 | 307 | 354 | 421 | 479 | 542 |
| 23                        | 75  | 136 | 167 | 252 | 310 | 356 | 422 | 480 | 545 |
| 35                        | 80  | 144 | 168 | 253 | 319 | 364 | 423 | 481 | 554 |
| 41                        | 90  | 149 | 170 | 254 | 321 | 366 | 424 | 482 | 555 |
| 42                        | 96  | 150 | 173 | 260 | 323 | 368 | 425 | 483 | 556 |
| 45                        | 108 | 151 | 174 | 262 | 324 | 371 | 426 | 484 | 562 |
| 47                        | 115 | 152 | 184 | 272 | 325 | 381 | 427 | 486 | 563 |
| 49                        | 117 | 154 | 186 | 273 | 326 | 385 | 430 | 487 | 566 |
| 51                        | 118 | 155 | 201 | 274 | 327 | 389 | 446 | 500 |     |
| 54                        | 122 | 159 | 208 | 277 | 330 | 399 | 449 | 514 |     |
| 64                        | 128 | 160 | 210 | 281 | 334 | 400 | 454 | 516 |     |
| Greenhouse and Laboratory |     |     |     |     |     |     |     |     |     |
| 26                        | 32  | 46  | 105 | 169 | 258 | 294 | 377 | 494 | 559 |
| 28                        | 33  | 53  | 110 | 179 | 290 | 313 | 379 | 499 | 565 |
| 29                        | 34  | 78  | 119 | 215 | 291 | 314 | 380 | 505 |     |
| 30                        | 36  | 97  | 142 | 233 | 292 | 349 | 492 | 507 |     |
| 31                        | 43  | 98  | 143 | 247 | 293 | 360 | 493 | 558 |     |
| Neotropical               |     |     |     |     |     |     |     |     |     |
| 1                         | 63  | 95  | 138 | 187 | 227 | 270 | 332 | 367 | 416 |
| 2                         | 67  | 100 | 139 | 188 | 229 | 271 | 333 | 370 | 417 |
| 4                         | 69  | 101 | 145 | 192 | 231 | 275 | 339 | 374 | 418 |
| 5                         | 71  | 102 | 146 | 193 | 232 | 276 | 340 | 376 | 428 |
| 6                         | 72  | 103 | 147 | 194 | 234 | 278 | 341 | 378 | 429 |
| 7                         | 73  | 104 | 148 | 198 | 235 | 282 | 342 | 386 | 431 |
| 9                         | 77  | 106 | 152 | 199 | 236 | 288 | 347 | 387 | 432 |
| 16                        | 79  | 107 | 153 | 200 | 237 | 295 | 348 | 390 | 433 |
| 17                        | 80  | 109 | 155 | 202 | 239 | 300 | 350 | 391 | 434 |
| 18                        | 84  | 111 | 156 | 203 | 242 | 303 | 352 | 393 | 437 |
| 24                        | 85  | 112 | 157 | 204 | 244 | 311 | 354 | 394 | 439 |
| 25                        | 86  | 114 | 158 | 207 | 245 | 312 | 356 | 395 | 442 |
| 37                        | 87  | 120 | 172 | 209 | 250 | 315 | 357 | 402 | 443 |
| 38                        | 89  | 121 | 175 | 218 | 261 | 316 | 358 | 407 | 444 |
| 40                        | 91  | 124 | 178 | 219 | 263 | 318 | 361 | 410 | 445 |
| 57                        | 92  | 125 | 180 | 220 | 264 | 320 | 362 | 412 | 447 |
| 59                        | 93  | 126 | 181 | 221 | 268 | 328 | 363 | 413 | 455 |
| 60                        | 94  | 132 | 183 | 226 | 269 | 331 | 365 | 415 | 459 |

## APPENDIX 3. Continued.

|                      |     |     |     |     |     |     |     |     |     |
|----------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 462                  | 471 | 501 | 512 | 523 | 529 | 543 | 553 | 569 |     |
| 463                  | 476 | 502 | 513 | 524 | 530 | 544 | 557 | 570 |     |
| 464                  | 481 | 506 | 515 | 525 | 531 | 549 | 563 | 571 |     |
| 466                  | 488 | 508 | 517 | 526 | 532 | 550 | 564 |     |     |
| 467                  | 489 | 509 | 521 | 527 | 533 | 551 | 567 |     |     |
| 469                  | 497 | 511 | 522 | 528 | 535 | 552 | 568 |     |     |
| <b>Paleotropical</b> |     |     |     |     |     |     |     |     |     |
| 2                    | 55  | 171 | 214 | 240 | 284 | 346 | 392 | 452 | 504 |
| 12                   | 81  | 176 | 221 | 248 | 287 | 353 | 396 | 456 | 512 |
| 13                   | 99  | 177 | 223 | 250 | 289 | 356 | 402 | 457 | 538 |
| 14                   | 109 | 183 | 225 | 256 | 301 | 357 | 407 | 458 | 539 |
| 22                   | 113 | 189 | 228 | 257 | 304 | 368 | 414 | 461 | 540 |
| 38                   | 127 | 193 | 235 | 259 | 307 | 369 | 440 | 468 | 541 |
| 39                   | 134 | 200 | 236 | 279 | 308 | 372 | 441 | 474 | 547 |
| 48                   | 165 | 206 | 237 | 280 | 328 | 375 | 450 | 501 | 560 |
| 52                   | 168 | 212 | 239 | 281 | 344 | 383 | 451 | 503 | 561 |
| <b>Temperate</b>     |     |     |     |     |     |     |     |     |     |
| 2                    | 76  | 137 | 205 | 266 | 332 | 397 | 435 | 477 | 546 |
| 19                   | 82  | 140 | 213 | 267 | 337 | 398 | 436 | 485 | 548 |
| 44                   | 88  | 141 | 227 | 296 | 355 | 401 | 438 | 491 |     |
| 50                   | 116 | 182 | 238 | 302 | 359 | 403 | 448 | 495 |     |
| 56                   | 122 | 185 | 241 | 305 | 373 | 404 | 460 | 496 |     |
| 61                   | 123 | 190 | 243 | 306 | 382 | 405 | 468 | 498 |     |
| 62                   | 130 | 191 | 249 | 309 | 384 | 406 | 470 | 520 |     |
| 67                   | 136 | 204 | 265 | 331 | 388 | 409 | 473 | 537 |     |

## COMPOSITION AND DISTRIBUTION OF THE VASCULAR EPIPHYTE FLORA OF AN ECUADORIAN MONTANE RAIN FOREST

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**ABSTRACT.** In a 175 m<sup>2</sup> sample plot of montane rain forest at 2,900 m elevation in southern Ecuador, a total of 33 families, 138 species and 3,454 stands of vascular epiphytes was found. Orchidaceae, Bromeliaceae, and Hymenophyllaceae were the most important families in terms of species richness, cover, and density. Epiphytic individuals of species that are normally terrestrial contributed greatly to the diversity. Most species had a narrow vertical distribution that in some cases was related to substrate preferences. Compared to lowland forests, the epiphytes in the montane forest had: higher density; a more even vertical distribution of abundance and diversity; and less pronounced dependence on humus accumulations.

Composición y distribución de las epífitas vasculares en un bosque montaño al sur de Ecuador.

**RESUMEN.** En una parcela de 175 m<sup>2</sup> en un bosque húmedo montaño a 2,900 m.s.n.m. en el sur del Ecuador se encontraron en total 33 familias, 138 especies, y 3,454 individuos des epífitas vasculares. Las familias más importantes en cuanto al número de especies, cobertura, y densidad fueron Orchidaceae, Bromeliaceae, Hymenophyllaceae, Dryopteridaceae, Polypodiaceae, y Ericaceae. Individuos epifíticos de especies que normalmente son terrestres, contribuyeron con mucho a la diversidad. La mayoría de las especies presentaron una distribución vertical estrecha que, en algunos casos, estuvo relacionada con las preferencias de sustrato. En comparación con los bosques de las tierras bajas, las epífitas de los bosques montaños tienen una mayor densidad, su distribución vertical de diversidad y abundancia fue más pareja, y su dependencia en acumulaciones de humus fue menos pronunciada.

## INTRODUCTION

Mid-elevation neotropical montane rain forests support the most abundant and species rich vascular epiphytic vegetation in the world (Madison, 1977; Gentry & Dodson, 1987). Several studies at altitudes between 500 m and 3,300 m support this claim (Grubb *et al.*, 1963; Sugden & Robins, 1979; Cleef *et al.*, 1984; Catling & Lefkovitch, 1989). According to these studies, maximum diversity values ranged from 24 to 91 species in sample plots of varying sizes at 1,700 m to 2,350 m. Maximum values for cover and density were found at similar altitudes.

Vascular epiphytes have specific vertical distribution patterns, and these patterns probably reflect different tolerances to light and humidity conditions (e.g., Schimper, 1888; Pittendrigh, 1948; Grubb & Whitmore, 1966; Johansson, 1974; ter Steege & Cornelissen, 1989). In lowland forests, the most abundant and species rich vascular epiphytic flora has been found on humus accumulations in forks or on large branches of the lower canopy (Johansson, 1974; ter Steege & Cornelissen, 1989). The ability of such humus deposits to buffer fluctuations in the humidity available to epiphytes, and their role as sources of mineral nutrients has been emphasized by Benzing (1987, 1989).

The purpose of this study was to quantitatively describe the composition and distribution of the vascular epiphytic flora of a montane rain forest in Ecuador, with special reference to vertical distribution and substrate preferences.

## STUDY SITE

The study plot was located 15 km south of Loja in southern Ecuador at 2,900 m, ca. 4 km east of Nudo de Cajanuma (79°10'W, 04°05'S). The plot (hereafter referred to as the Cajanuma plot) was located in undisturbed forest on a SW facing slope with 15% inclination, just north of the "Centro de Información" of "Parque Nacional Podocarpus."

Annual precipitation in the area is 2,000-4,000 mm, with a relatively dry period from July through September and a relatively wet period from February through April (Apolo, 1984). Easterly winds prevail, and since the study is located on a leeward slope 300 m below mountain ridge, it is probably subject to rain-shadow effect. Precipitation at the lower end of the quoted range is common occurrence of fog, for which no data are available. The epiphytic