

STUDIES ON ORCHIDACEAE ALKALOIDS—IV.¹

SCREENING OF SPECIES FOR ALKALOIDS 2

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Abstract—Further screening of *Orchidaceae* species for alkaloids² has been carried out and the analyses of 548 species are presented. Of these, 63 were found to contain more than 0.1 per cent alkaloid calculated on the dry weight, while a further 164 species contained more than 0.01 per cent.

TO BE able to draw any conclusion of taxonomic value from the occurrence of alkaloids in a group of species, it is important to know that approximate total concentration of the alkaloids present in each. For this reason, at least some of the tests used must give some idea about the concentration of alkaloids in the test solution. A test which only gives a positive or a negative reaction with all plant extracts, regardless of their alkaloid content, must be either discarded or modified. The original procedure for the qualitative detection of alkaloids given by Cromwell³ and followed by many authors, does not fulfil the requirements mentioned, but the improved micro-method by Abisch and Reichstein⁴ can be used with only minor modifications. This method is based on the following six tests: Dragendorff spot test, Mayer, Hager, Wagner, Sonnenschein and silicotungstic acid precipitation tests. Only if all six tests are positive, is the species considered to contain alkaloid. By comparing the amounts of precipitate formed in a test solution by Mayer's and Hager's reagent with those formed by the same reagent in a solution of known alkaloid concentration, and comparing the strength of colour in a Dragendorff spot test in the same way, it is possible to estimate the alkaloid content within a power of ten. The figures so obtained have been verified by actual isolation of alkaloids from several of the alkaloid-containing species,^{1,5,6} and are presented in alphabetic order in a condensed table using a short notation. The following signs for the total concentration a of alkaloids are used (the corresponding signs used in the previous paper² are given in brackets): $a > 0.1\%$, 5 [+ + +]; $0.1\% > a > 0.01\%$, 4 [+ +]; $a \approx 0.01\%$, 3 [+ (+)]; $0.01\% > a > 0.001\%$, 2 [+]; $a \approx 0.001\%$, 1 [(+)]; $a < 0.001\%$, 0 [-]. Further details of the experimental procedure are found in Paper I² of this series. All analyses were made on methanolic extracts prepared from fresh, living plants which were not dried before extraction. This is important, since many alkaloids are extensively destroyed and resinified and thus become nonextractable when the plant cells are killed slowly.

¹ B. LÜNING and K. LEANDER, *Acta Chem. Scand.* **19**, 1607 (1965); Part III of this series.

² B. LÜNING, *Acta Chem. Scand.* **18**, 1507 (1964).

³ B. T. CROMWELL, In *Modern Methods of Plant Analysis* (Edited by K. PAECH and M. TRACEY), Berlin-Göttingen-Heidelberg (1955).

⁴ E. ABISCH and T. REICHSTEIN, *Helv. Chim. Acta* **43**, 1844 (1960).

⁵ B. LÜNING and H. TRÄNKNER, *Tetrahedron Letters* 921 (1965).

⁶ B. LÜNING *et al.*, Unpublished results of current work.

RESULTS OF THE ALKALOID ANALYSES OF ORCHID SPECIES*

Acanthephippium mantinianum L. & C. 1; *A. sylhetense* Ld. 3; *Acineta superba* Rf. 0; *Acriopsis indica* Wi. 0; *A. javanica* Re. 4; *A. nelsoniana* Ba. 4; *Acrochoene punctata* Ld. 3; *Aerides jarckianum* Sr. 3; *A. quinquevulnerum* Ld. 3; *Agrostophyllum bicuspidatum* Sm. 4; *A. callosum* Sm. 2; *A. majus* Ho. 4; *A. sp.* 1201 3; *Angraecum philippinense* A. 5; *Anoectochilus lanceolatus* Ld. 3; *A. setaceus* Bl. 4; *A. tortus* K. & P. 2; *Anota violacea* Sr. 3; *Ansellia africana* Ld. 4; *Anthogonium gracile* Ld. 0; *Apostasia wallichii* Br. 2; *Appendicula cornuta* Bl. 4; *Arethusa bulbosa* L. 5; *Arundina bambusifolia* Ld. 0; *Barbosella* sp. P283 0; *Bletia campanulata* LL & L. 2; *B. purpurea* C. 4; *B. sp.* 663 2; *Botriochilus macrostachyus* Le. 2; *Brassavola acaulis* Ld. 5; *B. martiana* Ld. 2; *B. multiflora* Sr. 4; *Brassia allenii* Wm. 1; *B. chlorops* E. & Rf. 2; *B. gireoudiana* Rf. & Wz. 0; *B. longissima* Na. 1; *Bromheadia alticola* Ri. 4; *B. findlaysoniana* Rf. 2; *Bulbophyllum affine* Ld. 2; *B. baileyi* Mu. 2; *B. bisetum* Ld. 2; *B. bracteatum* Ba. 5; *B. careyanum* Sp. 2; *B. clarkeanum* K. & P. 4; *B. cuminghii* Rf. 2; *B. curranii* A. 4; *B. cylindraceum* Ld. 2; *B. dearei* Vh. 2; *B. gymnopus* Ho. 1; *B. hirtum* Ld. 0; *B. leysianum* Bu. 3; *B. listeri* K. & P. 4; *B. medusae* Rf. 4; *B. nematopodium* Mu. 4; *B. reptans* Ld. 2; *B. rigidum* K. & P. 2; *B. rufinum* Rf. 4; *B. sp.* P235 2; *Calanthe discolor* Ld. 4; *C. herbacea* Ld. 4; *C. japonica* Bl. 5; *C. labrosa* Rf. 4; *C. masuca* Ld. 4; *C. mexicana* Rf. 2; *C. rubens* Ri. 4; *C. sieboldi* De. 5; *C. veratrifolia* Br. 4; *Calypso bulbosa* Rf. 4; *Camarotis apiculata* Rf. 5; *C. philippinensis* Ld. 3; *Campylocentrum micranthum* Ro. 2; *C. brenesii* Sr. 1; *Catasetum cassideum* Li. & Rf. 4; *C. cernuum* Rf. 4; *C. dilectum* Rf. 2; *C. discolor* Ld. 3; *C. oerstedii* Rf. 2; *C. pileatum* Rf. 3; *C. saccatum* Ld. 4; *C. trulla* Ld. 4; *C. warszewiczii* Ld. 5; *Cattleya percivaliana* Ht. 2; *C. schroederiana* Rf. 2; *C. violacea* Ro. 3; *Chamorchis alpina* Rc. 4; *Chiloschista lunifera* Sm. 5; *Chondrorhyncha discolor* Ld. 3; *Cirrhopetalum caudatum* K. & P. 4; *Cleisostoma brevipes* Ho. 0; *C. gemmatum* K. & P. 3; *Coeologyne corymbosa* Ld. 0; *C. fuscescens* Ld. 1; *C. marmorata* Rf. 0; *C. ochracea* Ld. 0; *C. sparsa* Rf. 0; *Colax jugosus* Ld. 4; *Comparettia falcata* P. & E. 2; *Coryanthes macrantha* Ho. 1; *C. sp.* P309 1; *Cryptocentrum inaequisepalum* Sf. 0; *Cryptochilus lutea* Ld. 2; *C. sanguinea* Wa. 2; *Cryptophoranthus* sp. P325 2; *Cynoches aureum* L. & P. 2; *C. chlorochilon* Kl. 2; *C. egertonianum* Ba. 4; *Cymbidium atropurpureum* Ro. 3; *C. canaliculatum* Br. 0; *C. faberi* Ro. 5; *C. forrestii* Ro. 4; *C. gammieanum* K. & P. 2; *C. hoosai* Mk. 4; *C. iridifolium* Rx. 5; *C. lowianum* Rf. 4; *C. mastersii* Gr. 2; *C. pumilum* Ro. 4; *C. rubrigemmum* Hy. 2; *Cypripedium acaule* Ai. 0; *C. calceolus* L. 0; *C. macranthon* Sw. 0; *Dactylorchis sambucina* Ve. 2; *Dendrobium acerosum* Ld. 1; *D. adae* Ba. 4; *D. agrostophyllum* Mu. 4; *D. amethystoglossum* Rf. 0; *D. beckleri* Mu. 2; *D. bicameratum* Ld. 3; *D. bigibbum* Ld. 3; *D. blumei* Ld. 3; *D. canaliculatum* Br. 3; *D. cathcartii* Ho. 4; *D. ciliatum* Pa. 2; *D. clavatum* Wa. 4; *D. comatum* Ld. 0; *D. crassinode* B. & Rf. 2; *D. crystallinum* Rf. 2; *D. cucumerinum* Ly. 0; *D. dearrii* Rf. 4; *D. delicatum* Ba. 3; *D. denudans* Do. 2; *D. derryi* Ri. 2; *D. ecolle* Sm. 5; *D. falcorostrum* Fz. 2; *D. findleyanum* P. & Rf. 5; *D. fleckerii* R. & Wh. 4; *D. fugax* Sr. 4; *D. fusiforme* Ba. 4; *D. gracilicaule* Mu. 4; *D. grande* Ho. 4; *D. gratiosissimum* Rf. 2; *D. hispidum* Rh. 4; *D. jamesianum* Rf. 1; *D. johannis* Rf. 0; *D. kelsallii* Ri. 1; *D. koordersii* Sm. 5; *D. laciniosum* Ri. 4; *D. lichenastrum* Mu. 3; *D. linguella* Rf. 4; *D. linguiforme* Sw. 4; *D. lobatum* Mq. 4; *D. lohohense* T. & W. 5; *D. longicornu* Ld. 3; *D. lyonii* A. 4; *D. macrae* Ld. 2; *D. mannii* Ri. 5; *D. metachilum* Rf. 2; *D. monophyllum* Mu. 0; *D. mortii* Mu. 3; *D. padangense* Sr. 0; *D. pauciflorum* K. & P. 4; *D. phalaenopsis* Fz. 4; *D. porphyrochilum* Ld. 2; *D. pugioniforme* Cu. 4; *D. pusillum* Rx. 4; *D. pygmaeum* Ld. 3; *D. quadrangulare* Rf. 4; *D. schuetzei* Ro. 1; *D. scopa* Ld. 3; *D. senile* Pa. 0; *D. smilliae* Mu. 4; *D. spectabile* Mq. 4; *D. subulatum* Ld. 4; *D. taurinum* Ld. 2; *D. taylorii* Fz. 3; *D. tenuicaule* Ho. 4; *D. teretifolium* Br. 4; *D. tetragonum* Cu. 4; *D. toffii* Ba. 1; *D. topazianum* A. 4; *D. trigonopus* Rf. 4; *D. trinervium* Ri. 4; *D. undulatum* Br. 4; *D. uniflorum* Gf. 2; *D. victoriae-reginae* Lo. 2; *D. wardianum* Wr. 4; *Dendrochilum glumaceum* Ld. 3; *Dichaea muricata* Ld. 3; *D. sp.* P124, aff. *panamensis* Ld. 2; *D. trulla* Rf. 4; *Dipodium pictum* Rf. 4; *Elleanthus* sp. P1 4; *E. sp.* P222 0; *E. sp.* P223 2; *E. sp.* P12 1; *E. sp.* P322 1; *Epidendrum allenii* Wm. 5; *E. anceps* Jq. 5; *E. campylostali* Rf. 2; *E. crassilabium* P. & E. 1; *E. cryptanthum* Wm. 2; *E. equitantifolium* A. 4; *E. euosmum* Rf. 1; *E. exasperatum* Rf. 4; *E. filicaule* Ld. 4; *E. fuscopurpureum* Sr. 2; *E. incomptum* Rf. 4; *E. isomerum* Sr. 2; *E. lindleyanum* Rf. 4; *E. linearifolioides* Kr. 1; *E. moyobambae* Kr. 3; *E. myrianthum* Ld. 5; *E. oerstedii* Rf. 2; *E. paniculatum* R. & P. 4; *E. pauciflorum* Rd. 2; *E. polyanthum* Ld. 5; *E. pseudepidendrum* Rf. 2; *E. pygmaeum* Ho. 4; *E. purpurascens* Fk. 2; *E. ramosum* Jq. 2; *E. schlechterianum* A. 2; *E. schumannianum* Sr. 2; *E. sculptum* Rf. 4; *E. serronianum* Rd. 2; *E. skinnerii* Ba. 4; *E. sp.* P25 2; *E. sp.* P88 4; *E. sp.* P208 5; *E. sp.* P210 5; *E. sp.* P211 2; *E. stangeanum* Rf. 0; *E. stenopetalum* Ho. 2; *E. teretifolium* Sw. 4; *E. triangulabium* A. & Sf. 4; *Eria acervata* Ld. 3; *E. bambusaefolia* Ld. 2; *E. brachystachya* Rf. 2; *E. bractescens* Ld. 4; *E. clausa* K. & P. 4; *E. confusa* Ho. 4; *E. cylindrostachya* A. 5; *E. elongata* Ri. 4; *E. eriaeoides* Ro. 4; *E. flava* Ld. 2; *E. fragrans* Rf. 2; *E. graminifolia* Ld. 2; *E. irukandiana* Cl. 3; *E. javanica* Bl. 4; *E. multiflora* Ld. 0; *E. muscicola* Ld. 4; *E. queenslandica* Hu. 4; *E. rigida* Bl. 4; *E. rufinula* Rf. 2; *E. vittata* Ld. 4; *Erythroides killipii* A. 4; *E. querceticola* A. 5; *Eulophia geniculata* K. & P. 4; *E. graminea* Ld. 2; *E. keithii* Ri. 5; *E. squalida* Ld. 1; *Geodorum citrinum*. Jk. 4; *Gongora armeniaca* Rf. 0; *G. maculata* Ld. 2; *G. sp.* P326 2; *Goodyera foliosa* Bt. 4; *Govenia liliacea* Ld. 4; *Grammatophyllum scriptum* Bl. 4; *G. speciosum* Bl. 2; *G. stapeliaeflorum* Sm. 1; *Habenaria aristata* Ho. 4; *H. carnea* Br. 0; *H. viridis* Br. 2; *Hermidium angustifolium* Bt. 4; *Hetaeria nitida* Ri. 0; *Houlletia tigrina* Li. 2; *Huntleya melegris* Ld. (Pa.) 5; *H. sp.* P255 4; *Ione andersonii* K. & P. 0; *I. bicolor* Ld. 0; *I. intermedia* K. & P. 0; *Isabella virginialis* Rd. 2; *Junellea rigida* Sr. 3; *Laelia lueddemannii* Wm. 2; *L. moyobambae* Sf. 2; *Lankesterella oligantha* Hh. 2;

* See text for meaning of figures.

Leochilus labiatus Kz. 0; *L. sp.* P138 4; *Lepanthes sp.* P82 (new sp.) 5; *L. sp.* P298 2; *L. turrialvae* Rf. 2; *Liparis bistrata* P. & Rf. 5; *L. bituberculata* Ld. 5; *L. cathcartii* Ho. 5; *L. cordifolia* Ho. 5; *L. elata* Ld. 5; *L. elegans* Ld. 5; *L. longipes* Ld. 4; *L. platyrachis* Ho. 5; *L. reflexa* Ld. 5; *L. resupinata* Ri. 0; *L. vexillifera* Co. 5; *L. viridiflora* Ld. 5; *Lockhartia oerstedii* Rf. 2; *L. pittieri* Sr. 0; *Luisia inconspicua* Ho. 0; *L. teretifolia* Ga. 4; *L. trichorrhiza* Bl. 2; *L. volucris* Ld. 1; *Lycaste brevispatha* Kl. 2; *L. leucantha* Kl. 2; *L. macrophylla* Ld. 0; *Malaxis biloba* A. 4; *M. fastigiata* Kz. 5; *M. paludosa* Sw. 5; *M. siamensis* Se. & Si. 0; *M. soulei* Wm. 5; *M. sp.* P193 5; *M. sp.* 1142 5; *Malleola penangiana* Sm. & Sr. 5; *Masdevallia attenuata* Rf. 4; *M. sp.* P323 2; *Maxillaria camaridii* Rf. 2; *M. chartacifolia* A. & Sf. 4; *M. friedrichsthalii* Rf. 0; *M. fulgens* Wm. 2; *M. inaudita* Rf. 2; *M. repens* Wm. 0; *M. ringens* Rf. 4; *M. sp.* P29 0; *M. sp.* P71, aff. *Neourbania* 1; *M. sp.* P216 2; *M. sp.* P265 3; *M. sp.* P301 2; *M. valenzuelana* Na. 0; *M. variabilis* Ba. 1; *Mendoncella grandiflora* Hs. 2; *Mesospinidium warszewiczii* Rf. 2; *Microstylis khasiana* Ho. † 4; *M. wallichii* Ld. † 4; *Miltonia roetzii* Ni. 0; *Monomeria barbata* Ld. 3; *Mormodes sp.* P197 4; *M. sp.* P290 3; *Neomoorea irrorata* Ro. 4; *Nephelaphyllum cordifolium* Bl. 2; *N. grandiflorum* Ho. 4; *Nervilia aragoana* Ga. 0; *N. discolor* Sr. 2; *N. gammieana* Sr. 5; *N. macroglossa* Sr. 5; *N. plicata* Sr. 5; *N. scottii* Sr. 5; *Oberonia falcata* K. & P. 2; *O. fungum olens* Bu. 4; *O. iridifolia* Ld. 2; *O. longilabris* K. & P. 1; *O. pachyrachis* Rf. 2; *Octomeria sp.* P317 4; *Odontoglossum cariniferum* Rf. 2; *O. convallarioides* A. & C. 0; *O. oerstedii* Rf. 2; *O. schlieperianum* Rf. 1; *Oncidium ansiferum* Rf. 2; *O. asparagoides* Kr. 3; *O. cababae* Rf. 2; *O. cheiroporum* Rf. 1; *O. globuliferum* HBK. 4; *O. heteranthum* P. & E. 0; *O. panduriforme* A. & Sf. 0; *O. powellii* Sr. 0; *O. pulchellum* Ho. 0; *O. varicosum* Ld. 0; *O. warszewiczii* Rf. 2; *Ornithocepalus cochleariformis* Sf. 2; *O. inflexus* Ld. 4; *Ornithochilus fuscus* Wa. 2; *Otochilus alba* Ld. 2; *O. fusca* Ld. 0; *O. porrecta* Ld. 1; *Pachyphyllum sp.* 1394 4; *Panisea parviflora* Ld. 2; *Paphiopedilum argus* Pf. 4; *P. haynaldianum* Pf. 3; *P. lowii* Pf. 3; *P. philippinense* Pf. 0; *P. spicerianum* Pf. 3; *P. stonei* Pf. 2; *P. tonsum* Pf. 2; *Pelatantheria ctenoglossum* Ri. 1; *Pescatorea cerina* Ho. 4; *P. sp.* P256 4; *Phaius maculatus* Ld. 2; *P. mishmensis* Rf. 0; *P. wallichii* Ld. 4; *Phalaenopsis boxallii* Rf. 5; *P. decumbens* Ht. 5; *P. denevei* Sm. 4; *P. equestris* Rf. 5; *P. fuscata* Rf. 5; *P. gigantea* Sm. 5; *P. lueddemanniana* Rf. 4; *P. mariae* Bu. 5; *P. sanderiana* Rf. 5; *P. schilleriana* Rf. 5; *P. Stuartiana* Rf. 5; *P. sumatrana* K. & Rf. 5; *Pholidota articulata* Ld. 0; *P. imbricata* Ld. 0; *P. longibulba* Ht. 0; *P. protracta* Ho. 0; *Phragmipedium caudatum* Ro. 2; *P. longifolium* Ro. 4; *Phreatia elegans* Ld. 3; *Platyglottis coriacea* Wm. 2; *P. sp.* P149 2; *Pleione formosana* Hy. 0; *P. humilis* Do. 3; *P. maculata* Ld. 2; *P. praecox* Do. 2; *Pleurothallis alpina* A. 4; *P. antonesis* Wm. 2; *P. blaisdellii* Wt. 2; *P. cogniauxiana* Sr. 1; *P. crocea* Rd. 2; *P. immersa* Li. & Rf. 2; *P. leptotefolia* Rd. 2; *P. platysemos* Rf. 2; *P. quadrifida* Ld. 2; *P. recurva* Ld. 2; *P. sp.* P63 4; *P. sp.* P66 0; *P. sp.* P108 2; *P. sp.* P112 2; *P. sp.* P137 1; *P. sp.* P170 4; *P. sp.* P178 4; *P. sp.* P184 2; *P. sp.* P185 3; *P. sp.* P186 3; *P. sp.* P187 2; *P. sp.* P199 2; *P. sp.* P200 2; *P. sp.* P201 2; *P. strupitfolia* Ld. 2; *P. teres* Ld. 2; *P. tribuloides* Ld. 4; *P. uncinata* Fw. 4; *Podochilus cultratus* Ld. 4; *Pomatocalpa latifolia* Sm. 4; *Ponera australis* Co. 3; *Ponthieva racemosa* Bk. 2; *Porpax meirax* K. & P. 4; *Prescottia sp.* P142 1; *Promenaea xanthina* Ld. 2; *Pseudolaelia vellozicola* He. 2; *Renanthera monachica* A. 4; *R. storiei* Rf. 5; *Rhyncostylis coelestis* Rf. 2; *Riquezia spatulata* Sm. 4; *Saccolabium acutifolium* Ld. 0; *S. buccosum* Rf. 4; *Sarcantanthus appendiculatus* Ho. 2; *S. pallidus* Ld. 1; *S. subulatus* Rf. 4; *S. termissus* Rf. 4; *Sarcochilus ceciliae* Mu. 2; *S. falcatus* Br. 4; *S. fitzgeraldii* Mu. 2; *S. hartmannii* Mu. 4; *S. pallidus* Rf. 5; *S. sp.* 1305 5; *Satyrium nepalense* Do. 4; *Scaphyglottis amethystina* Sr. 2; *S. bilineata* Sr. 4; *S. lindeniana* Wm. 3; *S. sp.* P19 2; *S. sp.* P130 2; *Schomburgkia tibicinis* Ba. 3; *S. tompsoniana* Rf. 4; *Sigmatostalix abortiva* Wm. 4; *S. guatemalensis* Sr. 1; *S. racemifera* Wm. 2; *S. sp.* P123 2; *Sobralia sp.* P22 2; *S. sp.* P72 4; *S. sp.* P162 2; *Spathoglottis lobbii* Rf. 4; *Spiranthes cernua* Rc. 4; *S. funkiana* Rc. & Gl. 3; *S. speciosa* Rc. 2; *S. sp.* 933 2; *S. sp.* 1349 4; *S. sp.* 1395 2; *Stanhopea cirrhata* Ld. 2; *Stelis sp.* P57 2; *S. sp.* P59 1; *S. sp.* P60 4; *S. sp.* P136 1; *Stenorrhynchus orchioideus* Rc. 0; *Tainia hookeriana* K. & P. 2; *T. latifolia* Bt. 2; *T. minor* Ho. 4; *T. penangiana* Ho. 0; *Teuscheria pickiana* Gy. 1; *Thunia alba* Rf. 1; *Trichocentrum capistratum* Li. & Rf. 2; *T. fuscum* Ld. 4; *Trichoglottis fasciata* Rf. 2; *T. philippinensis* Ld. 1; *Trichopilia dasyandra* Rf. 1; *T. fragrans* Rf. 2; *T. maculata* Rf. 5; *T. marginata* Hf. 0; *T. sp.* P207 2; *T. suavis* Ld. & Px. 4; *T. turrialvae* Rf. 4; *Trigonidium lankesteri* A. 0; *Thrixspermum amplexicaule* Rf. 4; *T. arachnites* Rf. 4; *T. calceolus* Rf. 4; *Trizeuxis falcata* Ld. 2; *Tylostylis discolor* Ho. 2; *Vanda cristata* Ld. 5; *V. lamellata* Ld. 4; *V. luzonica* Lo. 4; *V. merrillii* A. & Q. 4; *V. roeblingiana* Ro. 4; *V. sanderiana* Rf. 4; *Vandopsis lissochiloides* Pf. 5; *Vanilla aphylla* Bl. 0; *V. chamissonis* Kl. 4; *V. planifolia* An. 2; *V. pompona* Si. 1; *Xylobium elongatum* Hs. 2; *X. powellii* Sr. 4; *Zeuxine goodyeroides* Ld. 2; *Zygopetalum mackayi* Ho. 2; *Z. maxillare* Ld. 4.

† These species should belong to *Malaxis* but so far I have not been able to find any valid transposition of them so I keep them in *Microstylis*.

A preliminary systematic treatment of the 1073 alkaloid analyses presented here and in the previous publication² has been performed in order to find out the taxonomic significance of the alkaloids in *Orchidaceae*.^{7,8} Using Pfizter's system⁹ for the systematic representation of

⁷ B. LÜNING, *Proc. Fifth World Orchid Conf.*, 1966. In press.

⁸ B. LÜNING, *Abstr.* 4-30. 4th Int. Symp. Chemistry Natural Products, Stockholm, 1966.

⁹ E. PFITZER, In *Die natürlichen Pflanzenfamilien* (Edited by A. ENGLER and K. PRANTL), Vol. 2, Part 6, p. 52. Leipzig (1887-8).

genera, it is evident that some taxa are definitely richer in alkaloid-producing species than others.

In *Diandrae* only one species with appreciable alkaloid concentration has been found, and since this taxon has been rather extensively investigated (50% of the species tested), one may say with some confidence that this group is rather poor in alkaloids.

Monandrae representing the main part of the family must be divided into smaller taxa to show any of its features. *Basitoniae* has not proven to contain any species with high alkaloid content, but since this group consists of terrestrially growing plants, the tropical members are difficult to obtain living and identifiable for investigation.

In *Acrotonae-Acranthae* the taxa *Convolvutae* and *Duplicatae* are rich in alkaloid-accumulating species, whereas *Articulatae* seems to be virtually alkaloid-free. The highest alkaloid content in *Duplicatae* is found in *Liparidinae*, with all the other taxa containing a number of species with high alkaloid content.

Acrotonae-Pleuranthae shows in the taxon *Convolvutae* a clearly higher alkaloid content in *Homoblastae* than in *Heteroblastae*, the former group comprising the genus *Chysis* containing chysine⁵ (3-methoxycarbonylpyrrolizidine) as well as the indigogenous species in the genera *Phaius* and *Calanthe*.

The *Duplicatae* form a more heterogeneous group, chemically as well as botanically. In this taxon we find such alkaloid-rich groups as *Dendrobiinae* or *Monopodiales* but also the large alkaloid-poor group *Oncidiinae*. The majority of alkaloids isolated from orchids have been found in the genus *Dendrobium* and six alkaloids with the dendrobine ring system have been identified in *D. nobile* Lindl. by Japanese workers.¹²⁻¹⁸ The 120 investigated *Dendrobium* species chosen to cover all sections of the genus give a probable picture of the alkaloid distribution, showing the subgenus *Eudendrobium* to contain most of the alkaloid-producing species, other centres being found in *Aporum* and *Strongyle*. In *D. primulinum* Lindl. we have found alkaloids¹ of a type differing from those found in *D. nobile*, and *D. parishii* Rehb. f. contains a quaternary imidazolium salt⁶ but no alkaloid. *D. crepidatum* Lindl. contains a small amount of dendrobine but the main alkaloids are not identical with the alkaloids found in any of the other *Dendrobium* species.⁶ A widespread alkaloid in *Orchidaceae* is hygrine found in e.g. *Catasetum*⁶ spp., *D. primulinum*¹ and *D. chrysanthum*,¹ mostly in combination with other alkaloids. In all hitherto investigated species of *Phalaenopsis* we have found a high concentration of only one alkaloid.¹⁰

This complicated distribution of alkaloids rather unlike that usually observed in alkaloid-producing families, can be resolved only by investigating their biosynthesis. It has been shown by us and by Japanese authors that mevalonic acid is built into the alkaloids of *D. nobile*.^{6,11}

The Brazilian species were obtained from Orquideário Catarinense, the Panamanian

¹⁰ B. LÜNING, H. TRÄNKNER and S. BRANDÄNGE, *Acta Chem. Scand.* **20**, 2011 (1966).

¹¹ M. YAMASAKI, M. MATSUO and K. ARAI, *Chem. Pharm. Bull. (Tokyo)* **14**, 1058 (1966).

¹² H. SUZUKI, I. KEIMATSU and M. ITO, *J. Pharm. Soc. (Japan)* **52**, 996, 1049 (1932); H. SUZUKI, I. KEIMATSU and M. ITO, *J. Pharm. Soc. (Japan)* **54**, 802, 996 (1934).

¹³ K. CHEN and A. CHEN, *J. Biol. Chem.* **111**, 653 (1935).

¹⁴ S. YAMAMURA and Y. HIRATA, *Tetrahedron Letters* **79** (1964); *Nippon Kagaku Zasshi* **85**, 377 (1964).

¹⁵ Y. INUBUSHI, Y. SASAKI, Y. TSUDA, B. YASUI, T. KONITA, J. MATSUMOTO, E. KATARAO and J. NAKANO, *Tetrahedron* **20**, 2007 (1964); *Yakugaku Zasshi* **83**, 1184 (1963).

¹⁶ T. ONAKA, S. KAMATA, T. MAEDA, Y. KAWAZOE, M. NATSUME, T. OKAMOTO, F. UCHIMARU and M. SHIMIZU, *Chem. Pharm. Bull. (Tokyo)* **12**, 506 (1964); **13**, 745 (1965).

¹⁷ Y. INUBUSHI *et al.*, *Chem. Pharm. Bull. (Tokyo)* **12**, 749, 1175 (1964); *Chem. Pharm. Bull. (Tokyo)* **13**, 1482 (1965); *Chem. Pharm. Bull. (Tokyo)* **14**, 668 (1966); *Chem. Ind.* 1689 (1964); *Tetrahedron Letters* 2723 (1965).

¹⁸ T. OKAMOTO *et al.*, *Chem. Pharm. Bull. (Tokyo)* **14**, 672, 676 (1966).

species were collected during a journey to Panama (Chiriqui, Coclé, Canal Zone), the Indian species came from Chandra's Orchid House and Superior Bulb Co., the Malayan species from Lin Orchids, the Philippine species from M. Fermin, the Australian species from Gold Coast Orchid Society and Limberlost Nurseries. A few species were collected in Sweden, U.S.A. and Guam by different helpful suppliers.

Species determinations have been performed with the aid of regional floras and when doubt has existed, by Dr. Leslie Garay, curator of the Orchid Herbarium of Oakes Ames at Harvard University. Dr. Robert Dressler made most of the preliminary species determinations of the Panamanian material in the field. Numbering of species refers to specimen plants in the live plant collection of the Institute.

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