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[1] Kanaseki, T., and N. Kokubu, *Quart. Rev. Taiwan Culture*, **5**, 9 (1950).
[2] Mabuchi, T., *et al.*, *Minzokugaku-Kenkyu*, **18** (1953).
[3] Chang, K. C., *Asian Perspectives*, **7**, 195 (1964).
[4] Dyen, I., *Intern. J. Am. Linguistics*, *Mem. 19* (1965); *Asian Perspectives*, **7**, 261 (1964).
[5] Chang, K. C., *Asian Perspectives*, **9** (1965).
[6] Chang, K. C., *Mainland Magazine*, **9**, 36 (1954).
[7] Chang, K. C., *Current Anthropology*, **5**, 359 (1964).
[8] Tsuboi, K., *Proc. Fourth Far-Eastern Prehistory Congr.*, **1**, 277 (1956).
[9] Tsukada, M., these PROCEEDINGS, **55**, 543 (1966).
[10] Chang, K. C., *The Archaeology of Ancient China* (New Haven and London: Yale University Press, 1963).
[11] Segawa, K., *Minzokugaku-Kenkyu*, **18**, 49 (1953).
[12] Kano, T., in *Studies in the Ethnology and Prehistory of Southeast Asia* (Tokyo: Yajima Shobō, 1952), vol. 2, p. 176.
[13] Sung, W. H., and K. C. Chang, *Bull. Dept. Archaeology and Anthropology, National Taiwan University*, **3**, 26 (1954).
[14] Observation and laboratory data supplied by Professor C. C. Lin.
[15] Oba, T., and C. S. Chard, *Asian Perspectives*, **6**, 75 (1963).
[16] Murdock, G. P., *Ethnology*, **3**, 117 (1964).

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*LATE PLEISTOCENE VEGETATION AND CLIMATE IN TAIWAN (FORMOSA)**

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Pollen analysis can help to establish past climatic changes, but data from the Asiatic subtropics have not been available. During 5 months of field work in 1964, led in Taiwan by K. C. Chang,[1] six lacustrine cores from Taiwan and five from Japan were collected. This paper traces the vegetational and climatic history of one lake core from almost the beginning of the last glacial age in Taiwan.

Present Vegetation.—Six major forest types cover the wide range of altitude in Taiwan today.[2,3] Four of these, directly related to the present palynological study, are briefly described here.

The subtropical rain forest (confined to the inaccessible lowlands below *ca.* 500 m in altitude) consists mainly of *Liquidambar formosana*, *Trema orientalis*, *Mallotus paniculatus*, *M. philippensis*, *M. japonicus*, *Diospyros* spp., *Celtis formosana*, *Styrax suberifolia*, Moraceae, and various bamboo species.

The warm-temperate forest (*ca.* 500–1,800 m), as characterized by the *Lauro-*

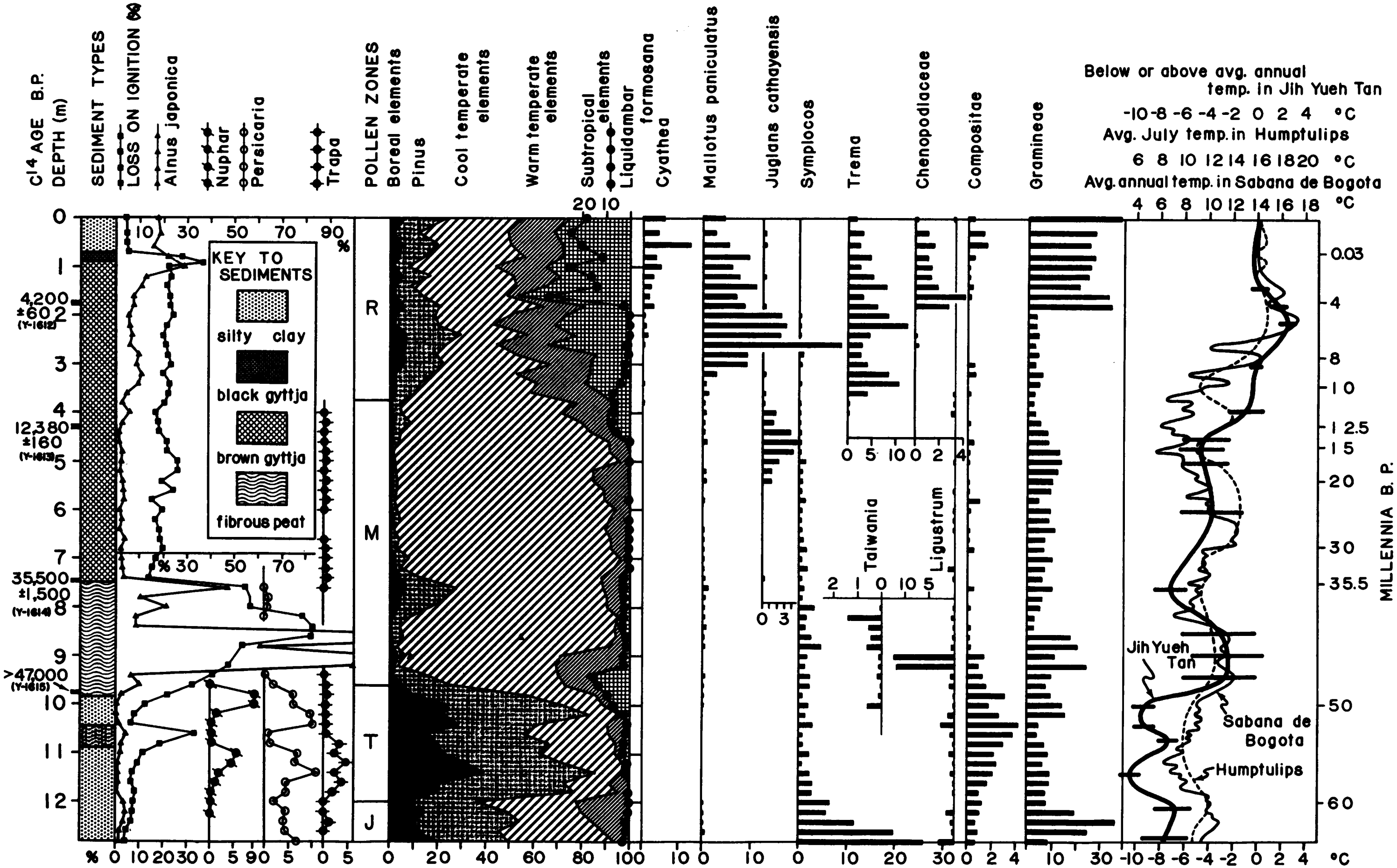

FIG. 1.—Pollen diagram for a 12.79-m core from Jih Tan (745.5 m), central Taiwan, showing sediment types in relation to loss on ignition, and pollen curves of *Alnus*, water plants, climatically grouped elements, and other selected species. At right, temperature curves from the present site, from Sabana de Bogota, Colombia,[11] and from Humptulips, Washington,[12] using a uniform scale for time as well as temperature, as far as the data permit.

Fagetum, includes predominantly *Castanopsis hystrix*, *C. carlesii*, *Cyclobalanopsis* spp., Lauraceae, and Theaceae together with many tree fern species. *Podocarpus macrophyllus*, *Keteleeria davidiana*, and *Cephalotaxus wilsoniana* are important conifers.

The cool-temperate forest (*ca.* 1,800–2,400 m) is composed of deciduous hardwood species such as *Cyclobalanopsis morii* (the predominant species), *Quercus* spp., *Ulmus uyematsuii*, *Zelkova serrata*, *Symplocos* spp., *Juglans cathayensis*, *Carpinus kawakamii*, and *Salix* spp., mixed with conifers, *Pinus morrisonicola Cunninghamia konishii*, *Taiwania cryptomerioides*, *Pseudotsuga wilsoniana*, and *Chamaecyparis formosensis*, but no species of *Castanopsis* grows in this forest. *The boreal forest* (>2,400 m) is formed by *Tsuga chinensis*, *Abies kawakamii*, and *Picea morrisonicola* mixed with *Pinus armandi*.

Methods.—Fossil pollen grains were extracted by the standard treatment of 10 per cent KOH, bromoform flotation (sp gr 2.28), HF, and acetolysis. The 65 identified pollen types comprise over 90 per cent of the total entities. A minimum of 500 grains was counted, excluding the pollen of *Alnus* and aquatic species, and spores. Because the prime object is to trace climatic changes, the basic sum for the percentage calculation includes climatically meaningful pollen types, i.e., *Pinus*, the boreal, the cool-temperate, the warm-temperate, and the subtropical elements. Each element consists of those pollen types that belong to the species or genera of the above four forest types.

Jih-Yueh Tan and Its Sediments.—Jih-Yueh Tan (745.5 m in altitude) occupies a fault basin in central Taiwan. The lake basin is divided by an island, Kuanhustao, into two parts with Jih Tan in the northeast and Yueh Tan in the southwest. The Jih Tan basin (23°52′ N lat., 120° 55′ E long.), from which a 12.79-m core was taken, was 5.0 m deep prior to the dam construction in 1934,[4] but it is now *ca.* 26.5 m. The stratigraphy here is represented on the far left axis of Figure 1.

The ignition loss curve (Fig. 1) shows the low organic content in the silty clay at the bottom and top parts, a rather uniform amount in the gyttja, and a sudden increase in the black gyttja (which contains noticeable H_2S). There is another abrupt increase as the sediment changes to compact fine fibrous peat from 10.95 to 10.40 m.

Pollen Zones and Vegetation History.—The four pollen zones, *J*, *T*, *M*, and *R*, are established in relation to a series of decreases or increases of the boreal and subtropical elements that clearly implies major climatic changes.

Zone J (*Jihtanian*) is characterized by a conspicuous occurrence of *Symplocos* pollen with some boreal elements (mainly *Tsuga chinensis*) and *Pinus* cf. *armandi-morrisonicola*. *Castanopsis* increases slightly toward the top of zone *J*. On the basis of four radiocarbon dates spaced through the core and the uniform sedimentation rate implied by more or less constant pollen densities, the *J*/*T* zone boundary is estimated at *ca.* 60,000 B.P.

Zone T (*Tali glacial*)[5] covers the time span of the maximal Tali glaciation, which may be the counterpart of the early Wisconsin in North America. This stage opens with a rapid expansion of the boreal elements and pine, and ends with the displacement of the boreal elements by the cool-temperate ones. The increase of pollen of aquatic plants (*Nuphar*, *Persicaria*, and *Trapa*) in the silty parts of zone *T* may imply that the lake level was less than 2.0 m during the Tali glacial maximum.

Zone M (*Milunian*)[6] is distinguished by the dominance of cool-temperate elements, but several species show some minor changes. The warmth-loving species, *Liquidambar formosana* and *Ligustrum*, increase temporarily near the *M/T* zone boundary. Shortly after the decrease of these species, *Pinus* and *Tsuga chinensis* show their small peak at 35,500 ± 500 B.P. (Y-1614). The occurrence of *Taiwania cryptomerioides* is limited to the early *M* zone from >47,000 (Y-1615) to *ca.* 35,500 B.P. *Alnus japonica* evidently was growing on the former Jih Tan bog, judging by the striking peak of alder in the peat deposits. Near the top of zone *M*, *Juglans cathayensis* suddenly appears, but decreases before the *M/R* zonal boundary. Gyttja sediments at the 4.25–4.35-m level are dated as 12,380 ± 160 B.P. (Y-1613). The *M/R* zone boundary is estimated at about 11,000 B.P.

Zone R (*Recent*) begins with the destruction of primeval forests, probably caused by early human activities, and with the rise of the subtropical and warm-temperate species, especially *Mallotus paniculatus*, *Trema* cf. *orientalis*, *Alnus*, and *Castanopsis*. The tree fern *Cyathea* invaded sites near Jih-Yueh Tan, presumably from the southerly direction, at the end of the Milunian, and then gradually established its present habitat. At the middle of zone *R*, dated as 4,200 ± 60 B.P. (Y-1612), the steep increase of grass pollen (*ca.* one third of the total grass pollen may be cereal species) together with *Liquidambar* and Chenopodiceae indicates intensified agricultural activities. The high frequency of pine and hemlock pollen may be due to long-distance transportation into rather open habitats made by forest burnings.

Climatic Sequence.—By logical induction, one can estimate climatic changes from a pollen diagram in such a piedmont district. Former altitudinal movement of one or a combination of several species is reflected in percentage changes at certain levels of the pollen diagram. This inferred range of altitudinal movement is multiplied by the standard lapse rate, 0.5°C/100 m, to yield an estimated change of mean annual temperature. The resulting climatic curve (heavy line at right of Fig. 1) is continuously drawn through mean values for each of the 20 levels, expressed as °C above or below the present annual mean.

Probably a moderate subtropical climate prevailed in the earlier Jihtanian, with acid soils containing iron oxides and aluminum hydroxides developed by laterization. But the cooling climate toward the full-glacial age inhibited laterization, and thus *Symplocos*, well known to be an oxylophyte, rapidly decreased toward the end of the Jihtanian. The temperature in zone *J* was 5.0–9.0°C lower than at present.

The maximal Tali glacial age includes three changes of climate, i.e., coldest, slightly warmer, and then colder. The plentiful, typical boreal forest at so low an altitude suggests a remarkable reduction of annual temperature, amounting to 8.0–11.0°C. The intermediate warm period was about 2°C warmer than the coldest period of the Tali glaciation, yet colder than any other late Pleistocene period. Taiwan was probably not an island in Tali time, and its climate must have been more continental, with a winter monsoon intensified by a cold coastal current. By using seasonal lapse rates and climatic data from Amoy, on the eastern coast of mainland China, monthly mean temperatures are computed for the Jih-Yueh Tan area during the glacial maximum. Calculated mean temperatures were 20.3 ± 0.31°C (July) and −4.1 ± 0.68°C (January); the winter temperature probably dropped to freezing even in lowland Taiwan.

Trapa, water chestnut, grows in eutrophic lakes,[7] and requires warm and clear summers for reproduction.[8,9] A colder, or at least a cloudier, climate caused extinction of *Trapa natans* from northern Europe in the sub-Atlantic and sub-boreal periods.[8] An explanation is needed as to why this plant, apparently sensitive to cold climate, increased during the Tali glacial period, but disappeared or decreased during the Milunian period.

A thermal index for plant growth is obtained by considering the amount of effective heat for photosynthesis or reproduction (e.g., by summation of mean monthly temperature above 5°C). Climatic data are available near the northern limit of present *Trapa* distribution at Lake Konoerkoje near Biisk, Altai region.[7,10] The total effective heat here is 52.5 month-degrees C. In the maximal Tali glacial period (using data from Amoy), the estimate is 54.2 ± 3.3 month-degrees C, which is very close to that of the present northernmost habitat. During that time, the temperature depression in growing seasons evidently did not fall below the critical limit. The later decline of *Trapa* pollen must therefore be attributed to edaphic changes (deeper water, followed by bog closure).

Subsequent to this marked coldness, a warmer climate came to lowland Taiwan. There were some fluctuations, but the vegetational index shows that the climate was still colder than it is today. The next major temperature lowering, marked by the temporary increase of pine and boreal elements, was some 5–8°C about 36,000 years ago. Since then, peat development in Jih-Yueh Tan may have been stopped by somewhat increased precipitation. The low frequency of *Trapa* in the brown gyttja formed during the Milunian stage may also be attributed to increased precipitation resulting in a much deeper lake. *Juglans cathayensis*, associated with *Cunninghamia konishii*, may give a reliable estimate of the mean temperature (lower by 2.0–6.0°C) between *ca.* 25,000 and *ca.* 14,000 B.P. The climate rapidly ameliorated from *ca.* 14,000 to *ca.* 12,000 B.P., favoring the growth of subtropical species in the lowlands. The Hypsithermal interval, recognized even in the subtropics by the expansion of *Mallotus paniculatus* and *Trema* cf. *orientalis*, may have been 2.0–3.0°C warmer than at present.

To obtain a clearer comparative picture of the climatic changes in the Asiatic subtropics, the data from Sabana de Bogota (2,560 m), equatorial Colombia,[11] and Humptulips (*ca.* 110 m), Washington,[12] are reproduced (with appropriately adjusted scales) in Figure 1. For the time scale of the Sabana de Bogota section, Flint and Brandtner's revised version[13] is adopted, but Heusser's original time scale for Humptulips is readjusted before *ca.* 30,000 years, i.e., beyond the oldest finite date, 27,400 ± 2,000.[12] Assuming that the sedimentation rate of the lower Humptulips peat is more or less the same as that of the upper half, the coldest period in the Humptulips section may be 50,000–60,000 B.P.

If the time scales of these three sites are valid, the general trend of the three curves is in good agreement. In Taiwan, however, the colest climate prevailed in the Tali glacial age, equivalent to the early Wisconsin or the early Würm glacial age. During the late Milunian age, corresponding to the late Wisconsin glacial age, the climatic depression in the Asiatic subtropics was not as great as that in glaciated parts of Europe and North America.

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[1] Chang, K. C., and M. Stuiver, these PROCEEDINGS, **55**, 539 (1966).
[2] Liu, T. S., *Ebk. Taiwan Nat. Hist. Museum*, **2**, 12 (1959).
[3] Li, H. L., *Woody Flora of Taiwan* (Narberth, Penn: Livingston Publishing Co., 1963).
[4] Miyadi, D., *Arch. Hydrobiol.*, **35**, 1 (1939).
[5] Wissmann, H. von, *Bull. Geol. Soc. China*, **17**, 145 (1937).
[6] Lin, C. C., *Taiwan Wen Shian*, **14**, 1 (1963).
[7] Turesson, G. von, *Botan. Notis.*, **3–4**, 177 (1932).
[8] Gams, H., *Pflanzenareale*, **1**, 39 (1927).
[9] Deevey, E. S., Jr., *Proc. Intern. Assoc. Theoret. Appl. Limnol.*, **12**, 654 (1955).
[10] Fickeler, P., *Der Altai, Eine Physiogeographie* (Gotha: Justus Perthes, 1925).
[11] Hammen, Th. van der, and E. Gonzalez, *Leids. Geol. Mededeel.*, **25**, 261 (1960).
[12] Heusser, C. J., *Ecology*, **45**, 23 (1964).
[13] Flint, R. F., and F. Brandtner, *Am. J. Sci.*, **259**, 321 (1961).

*THE TRANSFER OF LEARNED BEHAVIOR FROM TRAINED TO UNTRAINED RATS BY MEANS OF BRAIN EXTRACTS, I**

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A number of recent investigations have suggested the possibility that ribonucleic acid may play an important role in the recording of memory in the central nervous system. This speculation was supported particularly by Hydén *et al.*,[1–3] who found differences in base ratios between RNA from the brains of trained rats and RNA from untrained rats. In addition, experiments on planarians[4, 5] showed that the retention of a conditioned response by a regenerated tail section could be suppressed by ribonuclease, and suggested that the effects of learning might be transferred by cannibalism of trained worms. A re-examination of this finding, however,[6] demonstrated that what was transferred seemed to be a general activating effect rather than a specific learned response.

Despite the inconclusive outcome of these early experiments, two groups were led to attempt a transfer of learned responses in the vertebrate brain, making use of an extract containing RNA; both groups have reported positive results. The first of these investigations, by Fjerdingstad, Nissen, and Røigaard-Petersen[7] showed that an intracisternal injection of an extract from the brains of rats trained to run down the lighted alley of a maze facilitated the learning of the same task by recipient rats. While this result indicates an important difference between experimental and control groups, the fact that learning in rats is facilitated by their being fed yeast RNA,[8] as well as the demonstration of a general sensitization factor in