tively minor rôle in delaying the progress of the disease induced by reinfection with a virulent strain. The more striking results in regard to longevity and progress of tuberculosis obtained in the present series of experiments as compared to previous series are perhaps referable to various other factors, including route of virulent tubercle bacillus inoculation, *i.e.*, subcutaneous instead of intravenous, interval of time between inoculation and onset of intravenous ferric chloride injections, and finally, dose and virulence of bacilli employed. Experiments are now in progress in an attempt to answer these various questions. They will form the subject of a future communication.

VALY MENKIN

FROGS AND OPALINIDAE

CONCOMITANT studies of the taxonomy and geographical distribution of the Anura and their intestinal commensals, the Opalinidae, give indications of places and geologic times of origin and of the routes and times of spreading of all but one of the families of Anura, of some subfamilies and of several genera: and at the same time tell of the times and places of origin and of the routes and times of spreading of the Opalinidae, about 130 species of these Protozoa being included in the survey. A study of these problems has been in the hands of the editor for the United States National Museum since May, 1932, waiting only for the restoration of customary appropriation for printing. Such detailed study of origin and distribution has not been given before for any groups of animals. The data used are interwoven in intricate ways and are difficult to discuss without full description, but because of the unavoidable delay in publication it seems advisable to attempt the presentation of enough to show the kinds of data used, the methods of using them to bring out their significance and to illustrate the extent of the conclusions reached.

The data are: Present geographical distribution of the species and groups of Anura and of the species and groups of Opalinidae; the host distribution of Opalinidae; the taxonomic relationships of the groups of Anura; the interrelationships in detail of the Opalinidae, which show from their anatomy and their life-histories the course of their evolution in great detail; the agreement of present-day distribution of hosts and parasites with ideas of former intercontinental land connections and also seas, as commonly postulated by students of paleocartography.

It is of interest that the almost complete absence of paleontologic record of the Anura does not prove an insuperable bar to such evolutionary and paleodistributional studies. Evidence from the other sources mentioned proves adequate for profitable study and indicative of far-reaching conclusions.

The chief paleocartographical data used in these studies are: A Triassic continent, Gondwanaland plus South America (though the connection between Africa and South America may have been by way of Antarctica); a separation of Australasia from Malaysia, persisting since early Cretaceous times; Tertiary fluctuations in the Malaysian island connections, both with one another and with extra-Malaysian lands, which may have given brief connection between Papua and the southeastern Malaysian islands; a Cretaceous arm of the sea connecting the western Gulf of Mexico with the Arctic Ocean; a Cretaceous land strip from eastern Asia, running south of Alaska and down parallel to the western American coast and extending certainly to Central America and probably for a time to Ecuador or even to Chile (Tertiary connection of this strip was established with North America proper by the obliteration of the Gulf of Mexico-Arctic Ocean strait, and at the same time the southern portion of the land strip disintegrated); a Cretaceous or early connection of central or northern South America with Papuasia and Australia through the central Pacific islands; a bar to migration between southern Brazil and Patagonia, probably an arm of the sea or a strait, present in Cretaceous times or a little later and disappearing during the Tertiary, probably about the middle Miocene; an extended Antarctica, uniting Australia, New Zealand, Patagonia, sub-Antarctic islands in both Eastern and Western Hemispheres, and possibly Africa, the South American connection disappearing before the trans-Argentine sea was obliterated—Greater Antarctica was probably Cretaceous and persisted during the early Tertiary; an Indian Ocean continent, Lemuria, uniting Africa, Madagascar, Ceylon, southernmost India, the islands southwest of continental Malaysia and probably some of the southwestern Malay Archipelago islands (Lemuria existed in the Triassic, broke off from Africa during the Jurassic, and broke into separate islands before the end of the Tertiary). The data, discussed in the National Museum paper mentioned, agree with these paleocartographic conceptions, except for a single indication, namely, that there was a brief Tertiary connection between eastern Lemuria and continental Malaysia.

Let us note illustration of the handling of data in these studies. The Bell-toads evolved before the Cretaceous, since their spreading was not prevented by the Cretaceous separation of Australasia from Asia, they being present to-day in both Euro-Asia and New Zealand. They spread: North and west to Europe, where they are now represented; north and east to northern China (they are now present near the base of the Korean peninsula); south and east across Australia, where they left some of their characteristic

Protoopalinae of subgeneric group II, and on to New Zealand, this migration from Asia to New Zealand being as early as the early Cretaceous period or earlier, for the route was interrupted later than this. They passed from northeastern China on north and east by way of the land strip connecting Asia with the Western Hemisphere, during the Cretaceous period when this route was in existence. By the Tertiary time, when the land strip fused with continental North America, they had deteriorated in vigor and did not spread beyond western portions of Washington, Oregon and California, which were parts of the land strip. One Bell-toad is still found near the eastern Himalayas, the probable place of origin of the family. Two very decadent representatives of this decadent family are found at the extreme northeastern and southeastern limits of the range of the family: *Ascaphus,* a retiring form, confined to western Californian and Washington mountains, where it lives near the edge of glaciers, and *Liopelma,* in similar habitat in New Zealand. Though *Liopelma* has now lost its larval stage, its eggs hatching under stones in young adult form, and so, of course, showing no Opalinids, which can infect only aquatic tadpoles, the ancestors of *Liopelma,* then in less degenerate condition when they were crossing Australia, had aquatic tadpoles and characteristic Bell-toad *Protoopalinae* of subgeneric group II, through which they infected Australian frogs of other families, as found to-day. The places and times of origin and the routes and times of spreading to Australia of these secondary hosts are indicated in the fuller paper.

Another example of the use of data: *Cepedea* developed from *Protoopalinae* of subgeneric group VIII, which show transition to the multinucleate condition of *Cepedea.* They developed in Asia-Malaysia (where these *Protoopalinae* are alone found) in *Rana,* and spread to eastern Lemuria in the early Tertiary, both *Rana* and *Cepedea* being abundant in Madagascar, the Seychelles and Ceylon. *Rana* did not carry *Cepedea* via the Pacific land strip to North and South America. They evolved too late, after this route was lost. *Rana* did cross from Siberia to Alaska with *Cepedea* during the Tertiary, and both hosts and parasites have become abundant in North America, evolving many species. *Rana* and not *Bufo* was the early host in which *Cepedea* evolved and passed to Lemuria, as is indicated by the complete absence of *Bufo* from Lemurian lands to-day.

Opalina, a flattened, multinucleate genus, did not evolve from *Zelleriella,* a flat, binucleated genus, as it seems it might well have done by merely acquiring multinucleation. This is indicated by the fact that *Zelleriella* and *Opalina* do not occur and never have occurred in the same locality. *Opalina* arose from *Cepedea* by flattening; where and when involves complicated reasoning.

Similar indications as to times and places of origin and spreading of every family (except the Gastrophrynidae), of many subfamilies and genera and of a goodly number of species of Anura, and of every genus and numerous species and groups of species of Opalinids, can be found in the available data, in spite of such lack of fossils as would at first thought make these groups seem especially unfavorable for study.

The agreement of the conclusions as to the frogs and Opalinids with the generally postulated hypotheses of paleocartography is a striking evidence of the probable correctness of these hypotheses. An exception is in the presence of *Rana* and *Cepedea* in Lemurian lands, which has necessitated uniting eastern Lemuria and Asia-Malaysia, perhaps briefly, in the Tertiary.

The data used are varied, abundant and for the most part unquestioned, except the paleocartography. But with groups of parasites in which the course of their evolution is less assuredly indicated than it is with the Opalinidae a great aid to this type of study would be wanting. With the frogs and Opalinids it is like putting together a dissected picture puzzle of very many pieces. But when the pieces (data) finally fall into place, they make a consistent and convincing picture.

As this little paper is designed to emphasize the value and workability of the method of study, perhaps enough has been said without listing more of the many conclusions and indications found. That must be left for the fuller paper.

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