The »Experience« of Nature: From Salomon Müller to Ernst Mayr, Or The Insights of Travelling Naturalists Toward a Zoological Geography and Evolutionary Biology*

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Zusammenfassung

Wir beurteilen die Theorien und Beiträge früberer Autoren auf der Grundlage ihrer Relevanz für den heutigen Erkenntnisgewinn. Mit Blick auf die oftmals unzureichende Klärung der präzisen geographischen Herkunft von Materialproben bei nicht wenigen molekulargenetisch-phylogeographischen Studien (die an aktuellen Arbeiten demonstriert wird), soll die Bedeutung der geographischen »Erfahrung« (im doppelten Wortsinn) – am Beispiel der Erforschung des australasiatischen Raumes – untersucht werden.

Anfangs dominierten von staatlicher Seite initiierte bzw. finanzierte Forschungsreisen. Dazu zählen im Gefolge von James COOKS Fahrten durch den Indo-Pazifik beispielsweise die im frühen 19. Jahrhundert von Naturforschern wie QUOY, GAIMARD, LESSON, HUMBRON und JACQUINOT begleiteten französischen Expeditionen der *L'Uranie*, *La Coquille* und *L'Astrolabe* sowie die britischen Expeditionen der *Beagle* oder der *Rattlesnake* mit Naturforschern wie DARWIN oder MACGILLIVRAY und HUXLEY. Dazu zählt auch die holländische Expedition der *Triton*, an der der aus Deutschland stammende Naturforscher Salomon MÜLLER (1804–1864) teilnahm, der Jahrzehnte vor Alfred Russel WALLACE (1823–1913) scharfe Faunendifferenzen im indomalayischen Archipel erkannte und beschrieb.

Während diese Forschungsfahrten vorwiegend strategisch-militärische bzw. merkantile Ziele verfolgten, wurde die naturkundliche Erforschung im späteren 19. und beginnenden 20. Jahrhundert insbesondere von allein reisenden »naturalists« betrieben, wie etwa von WALLACE, Otto FINSCH (1839–1917) und Richard SEMON (1859–1918), der sich später Expeditionen wie beispielsweise von Erwin STRESEMANN (1889–1972), Bernhard RENSCH (1900–1990) und Ernst MAYR (geb. 1904) anschlossen. Deren Forschungen und Beobachtungen vor allem zum räumlichen Vorkommen von Faunenelementen und nahe verwandten Formen lieferten gleichsam den geographischen Schlüssel zu biogeographischen bzw. evolutionsbiologischen Phänomenen wie etwa der natürlichen Selektion, zu Faunenregionen und -grenzen (u. a. »Wallace's line« und »Wallacea«), Endemismen, Radiationen, Rassen- und Artenkreise sowie dem Prinzip peripherer Isolate und allopatrischer Speziation. Die Kenntnis des geographischen Faktors, der Kernstück des Beitrags der »naturalists« zur modernen Synthetischen Evolutionstheorie wurde, hat bis heute nichts von seiner Bedeutung für die Entwicklung und Formulierung zoologisch-evolutionsbiologischer Hypothesen eingebüßt, etwa im Rahmen einer Phylogeographie.

Summary

Science judges on theories and contributions by earlier authors on the grounds of their relevance and heuristic value for current studies and present knowledge. Compiling an abbreviated chronology and highlighting some relevant aspects and events, this paper investigates the importance and implications of geographical »experience« with focus on the historical development of scientific travelling and field research in the Australasian region. The earliest beginnings of European exploration in this area were dominated hy expeditions that were initiated, controlled and financed by official, i. e. governmental

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institutions, as is illustrated in the voyages by James COOK in the Indopacific or in the early 19th century by the journeys of naturalists such as QUOY, GAIMARD, LESSON, HUMBRON and JACQUINOT on board the French *L'Uranie*, *La Coquille* and *L'Astrolabe* as well as by naturalists like DARWIN, MACGILLIVRAY and HUXLEY on board the British vessels *Beagle* and *Rattlesnake*, respectively. Less well known and briefly described here is the Dutch expedition to New Guinea on the *Triton*. One of its participants, the German-born naturalist Salomon MÜLLER (1804–1864), was the first – albeit today largely unknown and forgotten – to discover a pronounced faunistic differentiation within the Malay Archipelago. MÜLLER explicitly described not only a sharp demarcation among the fauna that became later known as »WALLACE'S line« but also a characteristic region known as »Wallacea«, today both attributed to Alfred Russel WALLACE'S discovery of the same phenomena more than a decade later. It will be shown that the general claim, WALLACE was the first person to analyze faunal regions in SE Asia based on the distribution of multiple groups of terrestrial animals does not hold true in more than one respects.

While early expeditions had primarily commercial and/or strategical goals, natural history exploration in Australasia during the late 19th century was largely done by individually travelling naturalists such as WALLACE (1823–1913) or, less known Otto FINSCH (1839–1917) and Richard SEMON (1859–1918). During the early 20th century those were followed in Australasia, for example, by the expeditions of Erwin STRESEMANN (1889–1972), Bernhard RENSCH (1900–1990) and Ernst MAYR (born 1904). In particular the three journeys of the latter between 1928–1930 in New Guinea and the Solomon Islands, which will be outlined here, and, thus, the research and observations *in situ* provided the geographical key for the study of the spatial pattern of animal distribution and for understanding the origin of species and the mechanisms of speciation. It is these geographical data that facilitate insights into complex phenomena in evolutionary biology such as natural selection, faunal regions and their delineation, endemisms and radiations, *formenkreise* and superspecies, as well as the principle of peripheral isolates and the concept of allopatric speciation. Thus, providing the knowledge on geographical occurrence of faunal and floral elements over vast areas of the globe, has to be considered the main contribution of travelling naturalists toward the development of the modern synthetical theory of evolution. Within the framework of modern phylogeography this core research topic has not lost any of its relevance for the formulation and testing of zoological and evolutionary hypotheses, as is shown in light of the often very inadequate documentation of the geographical origin of certain samples used for molecular genetic and phylogeographic studies.

Introduction

> »A country having species, genera, and whole families peculiar to it, will be the necessary result of its having heen isolated for a long period, sufficient for many series of species to have been created [...] Therefore the natural sequence of the species is also geographical.«
>
> Alfred Russel WALLACE, 1855 (»The Sarawak paper«)

The »Golden Age« of zoology when naturalists on epic journeys travelled through largely unexplored regions of the globe, convincingly illustrated, for example, in accounts on the great age of Victorian explorations,[1] is long gone. Today, as it is at least often believed, zoologists only in their laboratories discover the new and unexplored. Especially those systematists who still conduct their research in the field often are misjudged as hopeless romantics who, by profession, satisfy their spirit of adventure and wanderlust.

Although often heard, this perception is unfounded. First, the majority of the roughly estimated 13 to 30 (or even up to 100) million animal species is still not yet discovered let alone scientifically described or studied in closer detail. Among this plethora of unknown biodiversity,

1 RABY 1996, RICE 2000.

the many invertebrate groups rank most prominently.[2] Second, this perception underestimates the importance of the geographical factor for zoology and the development of evolutionary biology. Thus, zoologists have to continue conducting research and explorations in the field not only for discovering species new to science, but also for the determination and evaluation of the distribution of species as providing the systematic and biogeographical foundation for other biological studies.

This paper investigates the contributions of some eminent 19th and 20th century naturalists and the importance and implication of the geographical »experience« toward the genesis of biological disciplines. »Experience« is to be understood here in two ways. First, I will briefly give an overview of the contributions of some of the most important explorations and expeditions that were instrumental to set the geographical stage, with a focus on Australasia as one of the biologically richest regions in the world. For example, naturalists such as Salomon MÜLLER, Alfred Russel WALLACE, Otto FINSCH and Ernst MAYR explored New Guinea in a scientific context including many of the diverse natural history objects. Second, I will investigate the importance of the geographical factor in zoology, highlighting the role that the spatial occurrence of taxa played during the last two centuries for the development of systematic zoology in particular and evolutionary biology in general.

Wallace's Program, Or the Genesis of Geographical Experience

In order to illustrate this »geographical principle«, the present paper will focus on the Malay Archipelago and the Australasian region. This region, later (and until today) to become mainly associated with the name of the 19th century naturalist Alfred Russel WALLACE (1823–1913),[3] is one of the richest areas in the world in terms of biological diversity and an ideal area for zoological studies in many respects.

It comes as a surprise that zoology itself learned only relatively late about the significance of the exact determination of the occurrence and distribution of animals. What is here named »WALLACE'S program« is, for example, illustrated by one of the earliest faunal accounts from the Indonesian Archipelago. The Dutch merchant, conchologist and founder-malacologist Georg Everhard RUMPHIUS (1628–1702) was certainly one of the greatest tropical naturalist of the 17th century, studying plants and animals of this region. Employed by the Dutch East India Company, he lived since 1654 in the town of Amboina on the Moluccan island of Ambon in eastern Indonesia. His famous opus »D'Amboinsche Rariteitkamer«[4] marks the beginning of

2 However, even today relatively large species among the comparatively well-known mammals remain to be discovered, as is illustrated by the Vu Quang bovid *Pseudoryx nghetinhensis* from Vietnam and the golden-brown mouse lemur *Microcebus ravelobensis* from Madagascar, to mention only two among many, as well as the many newly described, so-called cryptic species (GLAUBRECHT 2001, pp. 159–173).

3 For recent, well-documented biographies on WALLACE, certainly one of the most interesting and least celebrated travelling scientists, see WILSON 2000 and RABY 2001.

4 RUMPF 1705. RUMPF'S »Amboinsche Rariteitkamer« in Dutch was posthumously published in Amsterdam in 1705, with a second and third edition in 1740 and 1741; a Latin edition followed in 1711. A German edition of the second part, viz. on the molluscs of the 1705-issue, was prepared by Johann Hieronymus CHEMNITZ and published 1766 in Wien as »Amboinische Raritäten-Kammer«. Only recently, RUMPF'S book was translated into English in 1999 by E. M. BEEKMAN and published at Yale University Press as »The Ambonese Curiosity Cabinet«. For an account on G. E. RUMPF and

biogeographically orientated studies.[5] Ahead of his time, RUMPF in his »Curiosity Cabinet« not only used the binominal method half a century before LINNÉ established this procedure today considered obligatory in zoological nomenclature. RUMPF was also the first to give a faunistic inventory of a tropical marine fauna and a biological account emphazising, among others, the living molluscs of the tremendously rich but virtually unknown East Indies region. His magnificent work contains a wealth of first hand information on the biology and ecology of numerous species, thus rendering it the best scientific achievement of the time.

In addition, and in the context here even more important, he recorded the accurate localities of the animals he collected, described and depicted, emphasizing for the first time the geographical origin and the spatial dimension in zoology. After RUMPHIUS' epic approach to document the exact localities, it was only from the 19th century onward that this procedure was considered indispensable in a scientific publication. However, in spite of this growing tendency to record localities precisely in, for example, conchological monographs, »owners of collections at that period were not especially attentive to the identification of the native countries of the shells in their ›cabinets‹. This fault is still to be encountered«, as VON BENTHEM JUTTING pointed out.[6]

Although provincialisms were one of the first general features of land plants and animal distributions, these were recorded systematically by only a few of the 19th century scientists, like the zoogeographers SCLATER (1858) and WALLACE (1876). However, when biologists of this time travelled more and more routinely among different continents, they became impressed by the differences in biotas. Eventually the recognition of limited distributions of distinctive endemic forms suggested a history of local origin and limited dispersal, as revealed in the epitaph by WALLACE in the Introduction. Subsequently, this resulted in the (questionable) task to identify so-called »centers of origin«, to find evidence of historical barriers to dispersal or corridors for faunal exchange and to delimit the earth's biota into faunal and floral regions and provinces.[7]

Far into the 19th century, biologists only gradually began to appreciate the importance of recording exact localities. Although it is often stated, for example, that for the eminent British naturalist Charles DARWIN (1809–1882) the geographical distribution was the key to »unlock the mystery of species«,[8] DARWIN (1845) himself confessed in his journal of the voyage of the *Beagle* that he initially failed to note the exact location and geographical origin for the birds and reptiles he collected during his brief visit to Galapagos in September and October 1835. »I did not for some time pay sufficient attention to this statement [by the Vice-Governor of Galapagos, Mr. Lawson, that he could tell from which island any different form was brought],

his contributions to malacology see VON MARTENS 1902, VON BENTHEM JUTTING 1959 and STRACK and GOUD 1996; for some brief notes see also STRESEMANN 1951, pp. 37–40. For a long time it was unknown who, after RUMPHIUS' original drawings had been destroyed during a fire in Amboina in 1687, did the new figures (see, e. g., remark in VON BENTHEM JUTTING 1959, p. 193). Yet about at least 42 of the 60 plates of shells and minerals contained in RUMPHIUS' book were drawn and hand-coloured by the artist and engraver Maria Sibylla MERIAN (1647–1717) (see STRACK and GOUD 1996). For this work she had to arrange the material in a much more static comparative style than in her own, beautifully coloured and biologically insightful opus *Metamorphosis Insectorum Surinamensium*, also published in 1705 (see e. g. KAISER 1999).

5 GLAUBRECHT 2000.

6 VON BENTHEM JUTTING 1959, p. 183.

7 BROWN and LOMOLINO 1998; for a brief overview on the historical development in biogeography see e. g. GLAUBRECHT 2000 and literature therein.

8 For example BURCKHARDT and SMITH 1985, BOWLER 1990, RABY 1996, p. 32.

and I had already partially mingled together the collections from two of the islands. I never dreamed that islands, about fifty or sixty miles apart, and most of them in sight of each other, formed of precisely the same rocks, placed under the quite similar climate, would have been differently tenanted.«[9]

It might have been this confession that led WALLACE to clarify the zoological geography first of the Amazon region and later the Malay Archipelago.[10] Even more important in connection with his co-discovery of the mechanisms of natural selection shared with DARWIN, WALLACE much later recalled in his autobiography that »giving a mass of facts as to the distribution of animals over the whole world, it occurred to me that these facts had never been properly utilized as indications of the way in which species had come into existence«.[11] As BROOKS and SMITH have pointed out,[12] a space-time context for WALLACE'S many observations on animal distribution might have already developed during his travels up the Amazon. Given the insufficient distribution data available at that time, WALLACE apparently decided probably as early as 1846 that an intensive investigation of the facts and plant distribution is needed in order to determine how biological change took place.[13] This is documented, for example, in his 1852 paper on monkeys or his 1853 paper on the occurrence of distinct species of butterflies of the family Heliconidae on opposite banks of the Amazon.[14]

Starting from the observation that the distribution of biological diversity on the face of the earth is neither arbitrary and accidental nor the result of a divine plan, WALLACE (1876) with his systematic approach to the study of the occurrence of animals and plants single-handedly founded biogeography as a science in its own right. Although, of course, biogeography has many and also much earlier roots which cannot be investigated here in more detail, it is nevertheless true that both DARWIN and WALLACE obtained crucial impulses for their formulation of evolutionary theory from zoogeographical observation.

The increasingly detailed knowledge of the geographical distribution of organisms later also provided the indispensable tool for the foundation of the »new synthesis« in evolutionary biology, as it is first evident, for example, from the seminal accounts by RENSCH[15] and MAYR[16]. WALLACE'S program of determining the distribution of animals turned into a methodo-

9 DARWIN 1845, p. 287.

10 This hypothesis was put forward, to my knowledge, for the first time by David QUAMMEN 1996 in his insightful and well-documented popular science account. However, a detailed investigation into this possible connection and the beginning of biogeography as a systematic scientific discipline is still lacking albeit certainly worthwhile for students of the history of science.

11 WALLACE, 1905, pp. 354–355.

12 BROOKS 1984, p. 37, and SMITH 1991, p. 219.

13 SMITH 1991, p. 219.

14 In an earlier paper on the distribution of monkey species WALLACE already dropped some hints concerning his growing awareness of the significance of the precise distribution of species (see BROOKS 1984, p. 36; SMITH 1991, p. 219). Accordingly, the first of many pleas that naturalists should give more attention to recording the precise location is found there: »On this accurate determination of an animal's range many interesting questions depend. Are very closely allied species ever separated by a wide interval of country? What physical features determine the boundaries of species and of genera? Do the isothermal lines ever accurately bound the range of species, or are they altogether independent of them?« (WALLACE 1852, p. 110).

15 RENSCH 1929, 1947.

16 MAYR 1942. (1942); see, for example, MAYR 1982 and HAFFER'S 1997 exellent analysis of these early beginnings of the »STRESEMANN school« in Berlin.

logical research strategy for systematists and biogeographers in particular after the turn to the 20th century. This is marked, for example, in the work of the most eminent ornithologist of the time, Erwin STRESEMANN (1889–1972),[17] who wrote: »Was dem Systematiker einst als ziemlich nebensächlich galt, die Feststellung der geographischen Verbreitung, ist für ihn zu einem wichtigsten Forschungsziel geworden, [um] die genetischen Zusammenhänge der Formen zu erkennen.«[18] He later regarded the recognition of geographical variants as most critical and biologically important, since these geographical variants must be considered as instrumental in the speciation process.[19] HAFFER et al.[20] have investigated the scientific development and conceptional contributions to the evolutionary synthesis of the Berlin ornithologist and systematist STRESEMANN in a series of papers, to which the reader should refer. Here it is sufficient to emphasize that this historical development eventually led to the awareness of the importance of the geographical factor not only for variation and species delimination, but for speciation and evolution in general.

Importance of Collections

Today, exact data on localities and occurrences are still fundamental for biological, in particular (but not exclusively) biogeographical, studies. The determination of species distribution helps in pattern recognition and in process identification. Only accurate distributional data combined with the analyses of the phylogeny of taxa as well as the palaeogeography and palaeoecology of a given region allow us to look back in time.[21] The changed perception of the spatial origin and of natural differentiation in the distribution of animal and plants in the course of two centuries is also reflected in the development of natural history museum collections around the world.

Earlier collections were more or less arbitrary aggregation of curious natural history objects brought back from voyages that were at the beginning not primarily scientific expeditions. These natural science discoveries were housed as so-called »curiosities« in the various private or official predecessors of the later natural history museum collections. Todays most important scientific collections in the large natural history museums owe their oldest and thus historically most valuable objects to this fact, especially the traditional European natural history museums, such as the *Muséum d'Histoire Naturelle* in Paris (founded 1793), the *Natural History Museum* in London (founded 1859) or the *Museum für Naturkunde* in Berlin (founded as part of the Berlin University as early as 1810, re-established as a museum on its own in 1889).[22]

Not only did various natural history objects and the possession of respective collections become extremely fashionable in the 18th century,[23] but also later the natural history museums

17 For a biography and analysis of STRESEMANN's scientific contributions see HAFFER et al. 2000 and HAFFER 1997 and references cited therein.

18 STRESEMANN 1927, p. 7.

19 See, e. g. STRESEMANN and TIMOFEEFF-RESSOVSKY 1947, p. 57.

20 HAFFER 1997, 1999 and HAFFER et al. 2000 (and references cited therein).

21 See, e. g. GLAUBRECHT 2000.

22 For the development of natural history museums from »cabinets d'histoire naturelle« and the institutionalization of zoology see, for example, JAHN 1998, pp. 219–222, 331–336, for a later phase see SHEETS-PYENSON 1988.

23 See e. g. BURKHARDT 1995.

in Paris and London benefited considerably from the French and British explorations (which will be discussed in more detail below). One well-documented case of a very early, albeit more or less accidental, acquisition of natural history objects has been described by DANCE for a series of mollusc shells brought back by COOK's voyages.[24] Illustrating this growing awareness of natural history is the fact that for LAPÉROUSE's 1785–1788 (ill-fated) voyage to the South Sea, the French emperor LOUIS XVI and CLARET DE FLEURIEU compiled a detailed program of instructions for addressing many of the contemporary astronomical and geographical questions, but also for collecting »curiosités naturelles« of the land and sea.[25] Nearly each expedition during this time in Australasia discovered new plants and animals, and »there was hope that some of these might be naturalized and prove to be of economic value«.[26] As reported by JUSSIEU, for example, the rewards that the zoological collections alone received from BAUDIN's expedition to the South Sea (1899–1804) were enormeous, with 18414 new specimens representing 3872 species, 2542 of which were previously unknown.[27]

Accordingly, over the course of scientific exploration around the world during the 19th century the character of natural history collections shifted. More and more a research program became visible, leading eventually to a systematic collection effort and also including the exact documentation of the geographical origin of individual items. Recently, HAFFER has shown that in the study of birds (which are since then certainly the most well-known vertebrate group in terms of systematics and biogeography) it was the large collections arriving from foreign countries and distant places especially during the second half of the 19th century that turned the attention of European researchers to the study of natural history products from various geographical regions, in this case to exotic ornithology.[28] These collections at the museums, that form the basis for systematic and zoogeographical research on individual and geographic variation as well as biodiversity and evolutionary biology, steadily grew in Germany following the establishment of over-seas colonies after the early 1880s.[29] However, even far into the 20th century, it remained an often heard complaint that locations were insufficiently given, if at all, for specimens sent to museum collections rendering them close to worthless today for scientific purposes.[30]

24 DANCE 1971.

25 See »Voyage de La Pérouse autour du Monde, publié conformément au Décret du 22 Avril 1791, et rédigé par M. L. A. MILET-MUREAU. [4 tomes et atlas in-folio]. A Paris, l'an VI (1797)«. A somewhat similar detailed catalogue of instructions were compiled nearly a century later, for example, for the *Gazelle* expedition from 1874 to 1876 by some members of the »Königliche Akademie der Wissenschaften zu Berlin«, published as »Wissenschaftliche Wünsche zur geneigten Berücksichtigung bei Aufstellung der Instruction für S. M. Corvett ›Gazelle‹ (1874)«.

26 See BURKHARDT 1995, p. 119.

27 JUSSIEU 1804.

28 HAFFER 2001. For the late 19th century see SHEETS-PYENSON 1988. Another case study is the puzzling array of Australian vertebrates that arrived in European museum collections and long challenged the zoologists, described in MOYAL 2001.

29 HAFFER 2001, p. 33, Fig. 3; SHEET-PYENSON 1988.

30 To illustrate this common complain the following example may serve. FLANNERY et al. 1996, p. 9, who reported this annecdote, found a pencil annotation in a famous monograph on the tree-kangaroos of New Guinea published by W. ROTHSCHILD and G. DOLLMANN in 1936. Ellis TROUGHTON, who between 1908 and 1957 was curator of mammals at the Australian Museum, noted in pencil therein: »Lack of localities for figured animals serious oversight.« The presence of this note is ironic since TROUGHTON's own studies of tree-kangaroos were confounded by confusion regarding localities, leading to new species descriptions only due to misprovenance.

Early exploration of Australasia, 1511–1858

In contrast to the later increasingly systematic approach to the study of nature, the earliest objects that found their way back to the natural history collections were more or less arbitray side products of the earliest explorations. These were not so much motivated by interest in the study of natural products and/or phenomena *per se* than they were officially initiated and financed endeavours. Although undertaken from a mixture of motives, most expeditions and voyages until the late 18th century were not truely scientific journeys, but served primarily military, strategical, and commercial purposes. Here only an abbreviated survey can be given, compiled in Table 1, to which the reader should refer to for more details on the chronology.

In the Australasian region this era of strategical explorations begins with the voyages of the Portuguese who were the first Europeans to develop the technology and confidence to sail out of sight of land (with a fair chance of return), using a pivoted compass for direction and an astrolabe (or quadrant) to determine latitude.[31] As early as the 16th century they reached the coasts of New Guinea, but apparently successfully concealed their knowledge including the first existing maps. From the history of cartography it is evident that maps were always instrumental in the discovery of new areas as well as the distribution of geographical knowledge.[32]

With the formation of a united Dutch trading company in 1602, and after the successful 1615 sea battle at Malacca against the Portuguese, the Dutch took over power in Southeast Asia, ending the century long influence of the former in the Malay Archipelago. Following the jouneys of the Spaniard Luis Vaez DE TORRES 1606–1607 and the Dutch William JANSZ 1606, who both – each from opposite directions – sailed through the (later to be named) Torres Strait between New Guinea and Australia, the Dutch aggressively searched for sea routes to new markets and assembled their trading empire in the East Indies, extending soon eastward to the coasts of New Guinea and Australia (then called »Nova Hollandia«), which they gave its place on the map.[33]

Founded at the beginning of the 17th century the Dutch *Vereinigte Niederländisch-Ostindische Compagnie* managed to establish and maintain itself as a superior colonial power. For almost the next three centuries the VOC was not only dominating exploration but information on natural products in Southeast Asia. Many initial observations and objects reaching Europe have their source in the work of merchants and traders serving for the company. Georg Everhard RUMPF with his personal insight and experiences working *in situ* is only one, albeit prominent, representative of this era and its specific circumstances. With commercial and trading interests focusing on the exploration of tea, coffee, cacao, cinnamon, and other spices including the most valuable nutmeg[34] it

31 CLANCY 1995.

32 How printed maps became part of an essential infrastructure to support maritime interests since the Dutch discoveries, and how they record the evolution of geographical knowledge is well-illustrated for the Australasian region (which holds a central place in the world stage of cartography) in CLANCY 1995. A general assessment of maps as historical documents can be found in HARLEY 2001. For the discovery of pre-Cookian knowledge of Australasian geography see MCINTYRE 1982.

33 The contribution of Dutch explorers in official duty during this first phase of exploration is illustrated in detail in SCHILDER 1976.

34 For a lively and insightful account of Europe's competitive run to the »spice islands« see for example MILTON 1999. Originally, the nutmeg trees grew exclusively on six small and remote islands of the Banda group, including the island Run, about 2000 kilometers east of Jakarta. In the 17th century its fruit was believed to cure even the plaque, resulting in a 600 fold profit on the markets of Antwerp and London, thus triggering brutal battles between Dutch and British over the possession of the tiny islands. Although today not more than a footnote in world history, an exchange in 1667 between the British and Dutch who traded the island of Manhattan for the nutmeg island of Run certainly has changed the face of the earth.

Tab. 1 Strategic-scientific explorations in Australasia between 1511 and 1858 – an abbreviated chronology (compiled from various sources)

The Discovery of Australasia	
1511	the Portugueses ABREU and SERRANO reach Amboina and discover New Guinea
1526–1528	DE MENESES sent out to conquer Ternate in the Moluccas, reached 1526 coast of New Guinea, then named *Os Papuos* (later *Nova Guinea* by the Spaniard Alvaro DE SAAVEDRA in 1527 who reached it from the Moluccas)
1537	the Spaniards GRIJALVA and ALVARADO sail along New Guineas north coast
1567	Alvaro MENDANA DE NEYRA discovers Solomon Islands (only sighted again much later by CARTERET)
1595–1597	MENDANA also discovers Marquesas and Santa Cruz Islands (= Vanicoro)
1595	first Dutch expedition to East India
1598	Olivier VAN NOORT passes through Magalhaes-Strait, crosses Pacific
1601	Portuguese Manoel GODINHO DE EREDIA reaches Melville Island off Australia
1602	formation of the Dutch East India Company
1606	Willem JANSZ on *Duyfken* sails to New Guinea from Bantam, discovers west coast of Cape York Peninsula; Pedro FERNANDEZ DE QUIROS discovers the New Hebrides, named »Australia del Espiritu Santo« because thought to be part of the »Great South Land«
1606–1607	Luis VAZ DE TORRES sails to Manila through strait between New Guinea and Australia
1616	Willem Corneliszoon SCHOUTEN and Jacob LE MAIRE reach Australias east coast after finding third passage into the Pacific around Cape Horn; Dirck HARTOG on *Eendragt* reaches Australia's west coast at Shark Bay
1619	Frederick HOUTMAN'S and Jakob D'EDEL'S sighting of west coast of Australia
1622	Dutch *Leeuwin* sails around SW Australia
1623	Jan CARSTENSZ on the Dutch ship *Arnhem* lands on Australia's north coast, near Darwin, and discovers the Bay of Carpentaria and Cape York
1636	Gerard POOL reaches west coast of New Guinea, sails to 4.5° S
1642–1643, 1644	Abel Janszoon TASMAN circumnavigates the area containing Australia, discovers Tasmania (»Van-Diemens-Land«), New Zealand, Tonga and Fiji, Bismarck-Archipelago and New Guinea
1678	Dutch merchant KEYTS travels with three ships to south coast of new Guinea
1696	VLAMING reaches estuary of Swan River at Australia's west coast
1698	William DAMPIER discovers New Britain and DAMPIER'S Strait
1699	William DAMPIER first contact with Australia at Shark Bay
1700	DAMPIER reaches the NE coast of New Guinea, King Williams Cape (»A voyage to New Holland«, 1703)
1705	expedition of the *Geelvink* along New Guinea's north coast
1767–1769	Philipp CARTERET'S crossing of the Pacific without new discoveries
The Age of Natural Science Explorations in Australasia	
1766–1769	Louis Antoine DE BOUGAINVILLE on *La Boudeuse* crosses Pacific, reaches New Hebrides and New Britain, and narrowly misses east coast of Australia, on board botanist Philibert DE COMMERSON
1768–1771	James COOK'S first voyage on the *Endeavour* through the South Pazific, circumnavigating New Zealand, charting of Australia's east coast with botanists Joseph BANKS and Daniel Carl SOLANDER

Tab. 1 Strategic-scientific explorations in Australasia between 1511 and 1858 (continuation)

1772–1775	James COOK's second voyage on the *Resolution* and *Adventure* with naturalists Johann Reinhold FORSTER and George FORSTER
1774–1776	expedition of Thomas FORREST between the southern Philippines and New Guinea, lands near Dorey Harbour
1776–1780	COOK's third voyage to the Pacific
1776	French expedition to the Moluccas and New Guinea, with naturalist P. SONNERAT (1749–1814), in order to obtain nutmeg trees
1785–1788	Jean Francois DE GALAUP COMPTE DE LAPÉROUSE'S voyages on *Boussole* and *Astrolabe* in Melanesia and between New Guinea and New Zealand, with naturalist DUFRESNE
1788	British settlement (»The First Fleet«) at Sydney Cove
1789–1794	Spanish South Sea expedition of MALASPINA
1791	MACCLUER on *Panther* and *Endeavour* sailed along Australia's west coast and surveyed northwest and western coasts of New Guinea
1791–1793	Antoine Raymond Josef DE BRUNI D'ENTRECASTEAUX's coastal surveys in Australian and New Guinean waters, Admirality Islands and New Irland, on board as naturalist LABILLARDIÈRE
1801–1803	Matthew FLINDERS' *Investigator*, circumnavigation and cartography of Australia, a name recommended by him (»A Voyage to Terra Australis«, 1814)
1800–1804	Nicolas BAUDIN's French expedition on *Géographe* and *Naturaliste* to Australia and the South Sea, with naturalist Francois PÉRON
1817–1820	Louis-Claude DE FREYCINET's world circumnavigation with *L'Uranie* and *La Physicienne*, reaches also Timor and Waigeu, with naturalists QUOY and GAIMARD, LESSON, GARNOT
1822–1825	Louis DUPERREY's tour around the world on *La Coquille*, on board DUMONT D'URVILLE, and as pharmatists and naturalist (ornithologist) René P. LESSON
1826–1829	Jules Sébastian César DUMONT d'Urville's voyage on *L'Astrolabe* through the South Sea, on board QUOY and GAIMARD
1826	Dutch *Dourga* under KOLFF sailed into the (later so called) Princess Marianne Strait at New Guinea's SW peninsula
1828	Dutch expedition on *Triton* and *Iris* to SW coast of New Guinea, with naturalists Salomon MÜLLER, H. C. MACKLOT and A. ZIPPELIUS (botanist)
1837–1840	DUMONT D'URVILLE's second voyage around the globe on *L'Astrolabe* and *La Zelée*, exploring southwest coast of New Guinea (1839), on board naturalists HUMBRON and JACQUINOT (zoologist and commander on *Zelée*)
1843–1846	*Samarang* with naturalist Arthur ADAMS
1846–1850	Owen STANLEY's expedition on the *Rattlesnake* to New Guinea, Louisiade Islands, and north coast of Australia, trying to establish settlement there, with naturalist John MACGILLIVRAY and Thomas Henry HUXLEY as assistent surgeon
1849	Dutch *Circe* under BRUIJI-KOPS explores north coast of New Guinea
1858	expedition of the Dutch steamer *Etna* along New Guinea's coast
Maritime Expeditions that Later Explore Indowest-Pacific Waters	
1857–1859	Austrian expedition around the globe of the *Novara*, with Johann ZELEBOR as naturalist and zoologist to the expedition
1872–1876	*Challenger* expedition as first geophysical-biological exploration of oceans
1874–1876	*Gazelle* expedition around the world with emphasis on deep sea
1899–1900	Dutch maritime expedition on *Siboga* to Indowest-Pacific

is no wonder that botany became the *leitwissenschaft* of this epoch of exploration in the 17^{th} and 18^{th} century. In this context it is noteworthy that RUMPHIUS' first monumental work was also an important and illustrated botanical account, a large folio in six volumes *Herbarium Amboinense,* published posthumously between 1741 and 1755 but elaborated much earlier as his first major scientific contribution.

Only during the 19^{th} century would the region of the Malay Archipelago eventually be transformed from the exclusive domaine of the Dutch East India Company to the actual heart of imperialistic conquest by other nations, from commercial control converted into a treasure trove for natural history objects of more or less direct value. Whoever financed any expedition of exploration up to the end of the 18^{th} century had a clear commercial focus of finding and conquering new territories, establishing trading networks and, thus, on exploiting natural resources of newly discovered regions. This stringent focus with pronounced competitive commercial interests only gradually changed, in concert with a general improvement of all aspects of navigation (development of the octant in 1731 and the sextant in 1759 as well as accurate longitude measurement in 1765 using John HARRISON's chronometer)[35] and with a particular stimulus to scientific and accurate map making initiated first by the French and then the English in the 18^{th} century.

Under the influence of the age of Enlightenment in England and France scientific interests were added to the purely mercantile motives of maritime explorations. Prior to 1768 the Pacific geography was still very much fragmentary, as the earliest maps illustrate. Following the inital contributions to geographical knowledge by the explorer-navigator William DAMPIER (1651–1715), it was especially the official British Admiralty voyages during the 1760s by John BYRON, 1764 to 1766, Samuel WALLIS, 1766–1768, Philipp CARTERET, 1767–1769, and, above all, James COOK (1728–1779) with his three voyages between 1768–1780 that marked a change in the character and consequences of the maritime surveys of land and coastlines. At the end of the 18^{th} century these explorations initiated the turn to a new era.

The major contributions that significantly added to our knowledge of the natural history of the South Pacific and Australasia are highlighted in Table 1, listing expecially the British and French explorations, respectively. Undoubtedly, COOK's epic journey with the *Endeavour* as the first truely scientific voyage opened the new chapter of natural history expeditions. At the same time this remarkable voyage served as a model for future scientific explorations, making most if not all voyages of the late 18^{th} and the 19^{th} century Royal naval expeditions.[36] In COOK's case the Royal Society had chosen Tahiti (discovered 1767 by Samuel WALLIS) as a suitable place for the observation of the 1769 transit of the planet Venus in front of the sun. In addition to solving the mystery about an enigmatic *terra australis incognita*, that »darling of arm-chair geographers« as DANCE put it so aptly,[37] it was this astronomical phenomenon (eventually assisting to precisely calculate the distance between earth and sun) that formed the primary aim of COOK's first Pacific voyage on the *Endeavour* 1769–1771.

The two other objectives were geography and natural history of the places visited, i.e. to fix the exact positions of newly discovered islands and to study botany and zoology. For the latter purpose, the two botanists Joseph BANKS (1743–1820) and Daniel Carl SOLANDER (1733–1782) were ordered on board the *Endeavour*. This expedition eventually led COOK circumnavigating

35 The life and contributions of the 17th century British watchmaker John HARRISON (1693–1776), who first solved the problem of determination of longitude by using a chronograph, has recently been described by SOBEL 1995.

36 RABY 1996.

37 DANCE 1971, p. 357.

New Zealand and discovering and exploring the east coast of Australia, as well as in 1788 the choice of Botany Bay and (the more hospitable) Sydney Cove, respectively, for a British penal settlement, thus marking the beginning of a new epoch.

While COOK's first journey to the Pacific is generally considered the first *scientific* exploration, it is mostly overlooked that the voyage of his French counterpart, Louis Antoine DE BOUGAINVILLE (1729–1811), who entered the Pacific a few month before COOK, with the naturalist-botanist Philibert DE COMMERSON (1727–1773) and an astronomer on board of *La Boudeuse*, clearly showed the same character.[38] COOK and BOUGAINVILLE provided the framework for the explorers of succeeding generations,[39] opened up the Pacific and revolutionized existing maps of it. »Naval power, science and empire converged with superb economy.«[40] Following these explorers, naturalists systematically began to travel, to collect, to study, to draw and to describe the natural productions and biotic diversity protected and sponsored by admirality and governments.[41]

Beginning with Louis de BOUGAINVILLE's voyage around the globe 1766–1769 and comprising the next seven decades, the Australasian region also saw extensive discoveries accomplished by a series of major French expeditions,[42] accompanied by lavish government-sponsored journals. For example, following the disappearance of Jean Francois Comte DE LAPÉROUSE (1741–1788), the French coastal surveys in Australasia were begun 1791–1793 by Raymond Josef DE BRUNI D'ENTRECASTEAUX (1739–1793) with his hydrographer C. F. BEAUTEMPS-BEAUPRE and the naturalist LABILLARDIÈRE. Later the voyages of Nicolas BAUDIN (1754–1803) in 1800–1804 to Australia and the South Sea »pour des recherches de geographie et d'histoire naturelle«,[43] with Louis Claude FREYCINET being the expedition's cartographer, started an important sequence of French navigators. The natural history material collected during BAUDIN's expedition were given to the Paris Natural History Museum, with the majority being invertebrates studied by

38 The first man to be officially appointed as *naturalist* to accompany an expedition to the Pacific, and »probably the most competent observer of Pacific natural history in the eighteenth century«, as DANCE 1971, p. 355, has pointed out, was Georg Wilhelm STELLER (1709–1746) who accompanied several of Vitus BERING'S (1680–1741) expeditions to the north Pacific.

39 Interestingly, the chronology of discoveries and expeditions in Australasia reveales a continuous tradition in the skills of exploration (see Tab. 1), in which accompanying naval officers later became responsible for expeditions themselves, eventually leading to new discoveries, with BLIGH serving under COOK, FLINDERS under BLIGH, FRANKLIN under FLINDERS and STANLEY under FRANKLIN. The same can be seen in French naval history with FREYCINET first serving under BAUDIN and DUMONT D'URVILLE serving under DUPERREY before being commander on two marine voyages of his own.

40 RABY 1996, p. 5. The great Pacific voyages and the exploration of Australasia has been accused of heing a kind of »ecological imperialism« (see GASCOIGNE 2001 as, for example, illustrated recently in the correspondence of Joseph BANKS, botanist on COOK'S first voyage on the *Endeavour*, who was instrumental in founding the Royal Botanic Garden at Kew near London and whos aim was the movement of plants around the world; see CHAMBERS 2000).

41 Instrumental in as well as indicative of this process was, in addition to the formation of other learned societies and institutions with the age of Enlightenment and especially after the turn to the 19th century (see, e. g. RABY 1996, p. 7), the founding of the later influential Royal Geographical Society that published its first journal in 1832. The *Journal of the Royal Geographical Society* was to become the leading scientific medium available for explorers to publish the first news of their discoveries. Also, important contributions concerning the mapping and natural discoveries in the Malay Archipelago appeared here.

42 For an overview see e. g. DUNMORE 1965–1969.

43 JUSSIEU 1804.

the French biologist Jean Baptiste LAMARCK (1744–1829), providing him with rich and diverse material and, thus, a considerable scientific advantage for developing evolutionary views[44] that eventually would provide the basis for DARWIN's evolutionary revolution.

To highlight only a few cases from the chronological compilation given in Table 1, the collections and descriptions of the French naturalist René Primivére LESSON (1794–1849) should be mentioned. He was on board of the French corvette *La Coquille* that sailed round the world during the years 1821 to 1825. The expedition was unfortunate (like many other French enterprises in the Pacific) for all the natural history specimens collected prior to 1824 were lost in a shipwreck off the coast of Africa. LESSON was serving as naval surgeon on the *Coquille*, but had a strong interest especially in ornithology.[45]

Another example are the two French naturalists J. R. C. QUOY and J. P. GAIMARD on board of *L'Astrolabe* under the command of Jules DUMONT D'URVILLE (1790–1842) who circum-navigated the globe in the years 1826–1829. Their collections, for example, of molluscs from the South Sea with numerous descriptions of new species dominate the earliest malacological contributions from this region, published together with an atlas containing colourful folios in QUOY and GAIMARD (1832–1834).

Among the British contributions the naturalist John MACGILLIVRAY, who accompanied the expedition on the *H. M. S. Rattlesnake* that between the years 1846–1850 made discoveries and surveys in New Guinea and the Louisiade Archipelago, further increased the scientific knowledge of Australasia.[46]

As RABY has pointed out,[47] all these scientific voyages up to the mid 19^{th} century that preceeded the great age of Victorian explorations by individual scientific travellers were officially sponsored and financed. Thus, the journeys of most scientific explorers that catalogued the natural world and its history in the 19^{th} century were part of the imperial process, including those for example of Charles DARWIN (on board the *Beagle*), Josef HOOKER (on the *Erebus*) and Thomas Henry HUXLEY (on the *Rattlesnake*), to name only a few. Some went out as gentleman naturalists like DARWIN, others in payed duty as, for example, HOOKER and HUXLEY as assistant surgeons, or John MACGILLIVRAY as official naturalists. In concert with these commercial and/or military explorations the long-distance travelling naturalists until about the middle of the 19^{th} century, despite their individual and diverse personal motives, had one thing in common: it was indeed science in the service of the state.

This places them in contrast to a second group that begin to dominate scientific exploration in the course of the 19^{th} century, as will be shown in a separate chapter below. As not the least important consequence, these naturalists with their travelling experience were eventually instrumental in helping to bring up the scientific revolution in natural history that began with WALLACE and DARWIN.

44 See BURKHARDT 1995, pp. 119–120. An account of BAUDIN's exploration of Australia can be found in HORNER 1987.

45 For example, during a brief stay at the north coast of New Guinea, LESSON was the first European known who observed living birds of paradise and brought back some of the first skins of these birds; see STRESEMANN 1954.

46 Published »under the sanction of the Lords Commissioners of the Admiralty«, John MACGILLIVRAY's two volumes of his »Narrative of the voyage of the H. M. S. Rattlesnake«. London: T. & W. Boone 1852 also present – in a separate appendix and written by the experts of their time – individual chapters on particular groups of animals; among them is, for example, also an account on mollusca by Edward FORBES.

47 RABY 1996, p. 5.

The Dutch *Triton* Expedition 1828

Representing a relatively little known example of government-sponsored, naval exploration during the first half of the 19th century is the 1828 Dutch expedition with A. J. VAN DELDEN to New Guinea on board of the corvette *Triton* and the colonial schooner *Iris* under the command of Capitains J. J. STEENBOOM and J. H. VAN BOUDYCK BASTIAANSE, respectively. Undertaken by order of the Netherlands' government, on board of the two ships were also the naturalist Heinrich Christian MACKLOT (1799–1832) and the botanist A. ZIPPELIUS, in addition to Salomon MÜLLER as preparator and the two artists Pieter VAN OORT and Gerrit VAN RAALTEN. They were sent to the East Indies in Dezember 1825, arrived in June 1826 on Java, and finally were ordered to New Guinea in February 1828. They became known as the Natural History Commission for the Netherlands Indies, which was formed, in part, at the instigation of the director of the Leiden *Riijsmuseum van Natuurlijke Historie*, TEMMINCK (see below), in order to increase scientific knowledge of the Dutch colonial possessions.[48]

Both ships left Amboina in the Moluccas on April 21, 1828, not to return before September 5 the same year. The primary objective of the expedition was to secure Dutch power in western New Guinea in particular against British interests by establishing a settlement on some convenient spot on the west coast of the island. Although VAN DELDEN's report was never published, detailed accounts of the voyage were given by J. MODERA[49] and later Salomon MÜLLER[50] (e.g. 1858) as the sole survivor of this ill-fated expedition.[51]

The *Triton* expedition did not reach its primary aims due to many adverse circumstances (an unfortunate »Verkettung unglücklicher und unvorhergesehener Umstände«),[52] but especially due to the failure of finding a suitable landing place for the settlement. In addition, the climate in this region of New Guinea was cold, damp and foggy throughout most of the prevailing southeast monsoon months. Consequently, the majority of the crew including the five scientific men suffered from »jungle fever« (i. e. malaria) at their main anchorage, Merkusood at Lobo in Tritons Bay and the Fort Du Bus. After the death of twenty of the ships' crew and the sickness of about sixty others that »made further research impracticable«,[53] the expedition was finally forced to return to Kupang on Timor, where the naturalists including Salomon MÜLLER left the expedition with the plan to continue natural history observations in the west part of this island. Based on a 13 months stay, MÜLLER in his second volume later reported on the geography and ethnography of Timor.[54] On this island with ZIPPELIUS the first member of the scientific party died on December 28, 1828 and was followed by VAN RAALTEN in April 1829, while MACKLOT was killed during a riot on Java in May 1832 (loosing also his scientific notes). After the last member, VAN OORT, died in September 1834, it was only Salomon MÜLLER to return to Europe.

48 STRESEMANN 1951, FLANNERY et al. 1996.
49 MODERA 1830. MODERA'S' account on the *Triton* expedition, published in Dutch, was later translated and reported as »Narrative of a vogaye along the S. W. coast of New Guinea, in 1828« in the *Journal of the Royal Geographical Society of London* Vol. 7, 383–395 (1837), communicated by the same George Windsor EARL who was first to publish on the physical geography of the Malay Archipelago (see e. g. EARL 1837, 1845) long before Alfred Russel WALLACE.
50 MÜLLER 1858.
51 See also WICHMANN 1910 for an annotated overview of the *Triton* expedition.
52 WICHMANN 1910.
53 MÜLLER 1858, p. 265.
54 MÜLLER 1857.

Nevertheless, the *Triton* expedition was of considerable success in two other respects. First, during this voyage the greater portion of the SW coast was surveyed, being the first detailed and systematic cartographic study of New Guinea (Fig. 1), with the *Triton* and *Iris* being the first ships to sail into the Princess Marianne Strait from the north. Second, a rich collection of natural history objects from New Guinea were, for the first time, systematically collected and later thoroughly described mainly by Salomon MÜLLER.[55] For example, MODERA[56] and MÜLLER[57] both reported on several species of kangaroos (»vele soorten von springhazen«), later leading to the description of the new genus *Dendrolagus*. Among other contributions, this renders MÜLLER and MACKLOT pioneering biologists and the first Europeans »to leave a clear account of a tree-kangaroo in life«.[58] In addition to mammals, amphibia, reptiles and fishes, the birds hunted by the expedition's crew were especially rich, among them birds of paradise, crown pigeons, and kingfishers. »At the end of the voyage, and of a three months' stay on the coast, our collection was composed of 119 varieties, belonging to 60 different kinds.«[59] This material mainly found its way to the *Riijsmuseum van Natuurlijke Historie* in Leiden, undoubtedly contributing to the fact that, during the 19th century, it held one of the most famous collections.

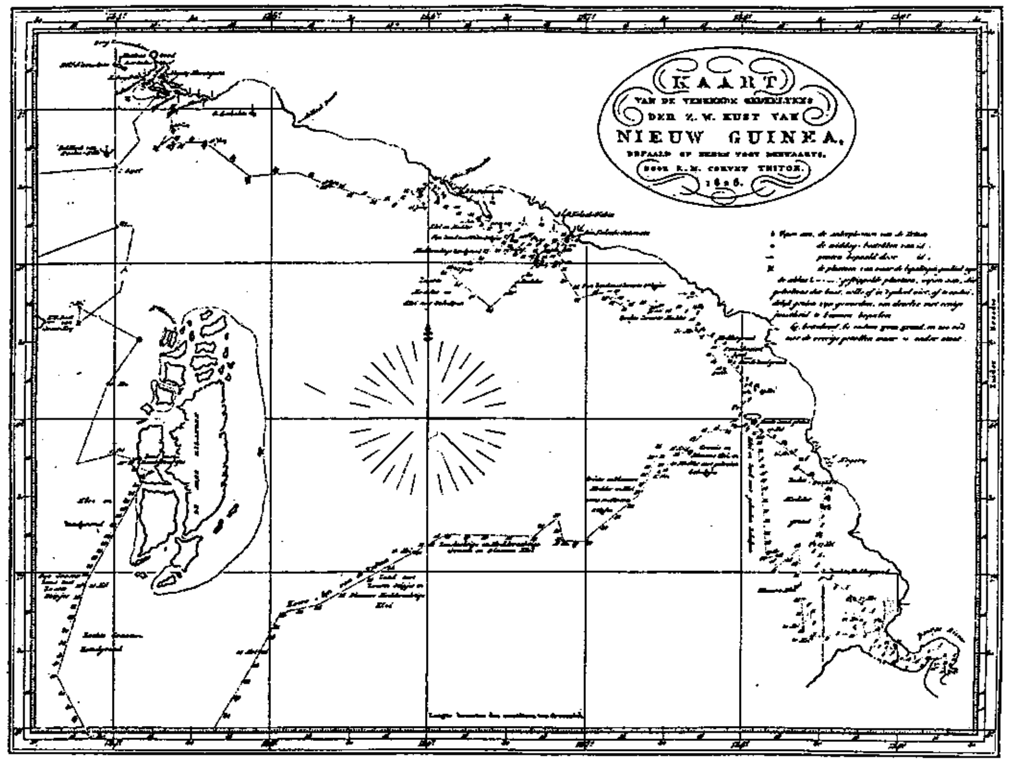

Fig. 1 SW coast of New Guinea surveyed during the Dutch *Triton* expedition 1828. From MODERA 1830

55 In addition to the fauna, an account of the various plants collected during this voyage by the botanist ZIPPELIUS was published in 1829 in a Dutch periodical, the *Konst-en Letterbode* (vol. I, pp. 294 ff.).
56 MODERA 1830.
57 MÜLLER 1858, p. 269.
58 FLANNERY et al. 1996.
59 MÜLLER 1858, p. 270.

Salomon Müller and the Foundation of a »Zoological Geography«

> »Welcher Unterschied daher in der thierischen Welt jener östlichen Hälfte und der westlichen des Archipels.«
>
> S. MÜLLER (1846)[60]

The German naturalist Salomon MÜLLER was born on April 7, 1804 in Heidelberg; he also died in Germany, viz. in Freiburg im Breislau in spring 1864.[61] His parents were Johann Gottlieb MÜLLER, »Bürger und Sattlermeister«, and his wife Maria Elisabeth (maiden name HELFRICHIN). Between 1826 and 1837, Salomon MÜLLER spent eleven of his best years (*»elf der schönsten Jahre meines Lebens«*)[62] in the Malay Archipelago, thus three years more than Alfred Russel WALLACE two decades later. The circumstances of MÜLLER's employment in the *Natuurkundige Commissie van Nederlandsche Indie* (member of the Dutch commission of natural history in East India) was described in some detail only by STRESEMANN.[63] After his return to Europe MÜLLER, who also held a doctor's title, became *Ritter des niederländischen Löwenordens* (Knight of the Order of the Dutch Lion) and continued to work in the museum in Leiden.

Having been employed not as naturalist but as *»Präparator«* to the expedition, he was originally only responsible for stuffing and preparing the collected natural history objects. However, MÜLLER miraculously was not only the sole surviver of the 1828 *Triton* expedition to New Guinea, but he also remained in the East Indies for nearly another decade and went successfully on several other journeys through the Malay Archipelago before returning on August 22, 1837 to Holland. First, he travelled on Sumatra in 1833–1835. A year later he made a journey from Bandjermasin in the south of Borneo up the river Barito (Soengi Doeson, or Banjer) to Lontontoer just south of the equator, through the region of the sultanat Martapoera and the Lawut-Landen in the province Laut. A detailed report about these journeys on Borneo, undertaken in 1836–1837 in company of Ludwig HORNER and the botanist P. W. KORTHALS, is given in MÜLLER's first volume of »Reizen en onderzoekingen«, while the journey to New Guinea and his travelling on Celebes, Boeton, Ambon and the Banda Islands is described in the second volume.[64]

In light of the experiences of the *Triton* expedition in 1828, and given the obstacles and dangers that remain daunting even for modern biological explorers in many region of Indonesia, it was nothing short of miraculous that MÜLLER – as did WALLACE from eight years of travelling in the same region – emerged alive from the East Indies to return to the Netherlands.

As a direct result of the later journeys MÜLLER can be credited with first having cartographed the wide inland from Bandjermasin on Borneo (see Fig. 2). Even more important in our context, he also explored much of the biological diversity not only on New Guinea during the *Triton* expedition (see above) but also on the Sunda Islands he travelled in the 1830s. The combined

60 S. MÜLLER 1846, S. 114.

61 The few existing biographic dates on Salomon MÜLLER are to be found e.g. in HENZE 1993. STRESEMANN 1939, p. 303, reported in a footnote in his introduction to the history of research on Celebes that up to his research into this matter the year of birth of MÜLLER was unknown (and was indeed hitherto given as »around 1800«) as were his parents and their profession; see also STRESEMANN 1951, pp. 138 ff.

62 MÜLLER 1846, p. 127.

63 STRESEMANN 1951, pp. 135–145, 154.

64 MÜLLER 1857

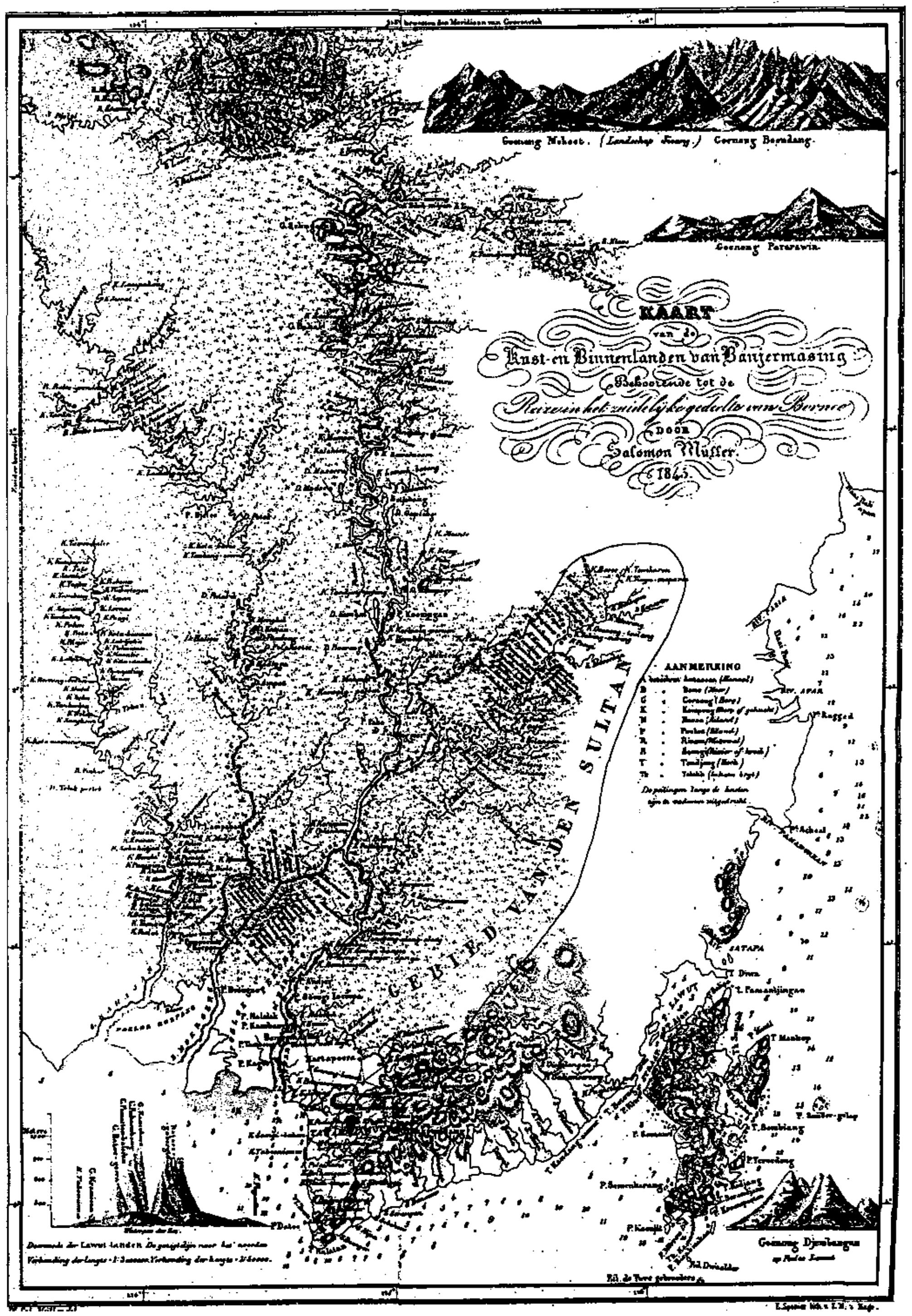

Fig. 2 Salomon MÜLLER first cartographed the wide inland from Bandjermasin on Borneo. From MÜLLER 1857

experiences and observations on animals from these two geographical regions, in particular on mammals but also birds and reptiles, provided the basis for his later evaluation of a distinctive faunistic division within the Malay Archipelago.

Immediately following his return 1837 and strongly supported by the director of the *Rijksmuseum* in Leiden, Coenraad Jacob TEMMINCK (1778–1858), several faunal elements new to science – from orangutan and marsupials to birds of paradise and varans – were described by Salomon MÜLLER himself, or by Hermann SCHLEGEL (1804–1884; in 1858 to become museum director after TEMMINCK died) and Wilhem DE HAAN (1801–1855) in a series of illustrated publications.[65]

To the documentation and descriptions of the findings and the material collected during his travelling, MÜLLER later added two accounts on the geography of animals in the Malay Archipelago that were analytical in its best sense. The first paper written in German (in contrast to his later book on his journeys)[66] was published in March and April 1842 in two consecutive issues of the *Annalen der Erd-, Völker-, und Staatenkunde*. Here he begins his detailed analysis of the distribution of mammals on the individual islands of the Sunda group and the Moluccas with the statement that »wiewohl alle Inseln, von Java bis Neu-Guinea fast dasselbe Klima haben, und viele von ihnen ziemlich dicht bei einander liegen, ja oft nur durch schmale Meerengen von einander geschieden sind, so besitzt doch jede Insel von einiger Ausdehnung in grösserer oder geringerer Anzahl Gattungen, welche ihr eigenthümlich sind.«[67]

In the subsequent paragraph, he continues: »Es verdient bemerkt zu werden, dass die grossen Sunda-Inseln sehr viele Geschlechter von Säugethieren besitzen, wovon man auf den etwas östlicher gelegenen Molukkischen Inseln keine Spur mehr antrifft, während diesen wieder einige andere eigen sind, die auf jenen ganz und gar vermisst werden.«[68]

After having presented in the first part (published in March 1842) only a brief overview on the distribution of mammals, a second, more detailed account comprising and reviewing the then available biological observations on each mammalian taxon in the area, was published in the 1842's April issue. According to MÜLLER's statement,[69] it was based on his »own observa-

65 A series of monographic papers by these three naturalists were edited by C. J. TEMMINCK (for an insight account on his personality and accomplishments see STRESEMANN 1951, pp. 150–155) and appeared as *Verhandelingen over de Natuurlijke Geschiedenis der Nederlandsche Overzeesche Bezittingen. Zoologie* in Leiden, published between 1839 and 1845 by the *Natuurkundige Commissie in Indie*. Here, MÜLLER often credited Heinrich Christian MACKLOT (1799–1832) with co-authorship, apparently to honour him for his contributions during the exploration on New Guinea and Timor, altbough the latter has died before returning. TEMMINCK'S Dutch monograph series contained the very first illustrations of New Guinean animals. Most spectacular is, for example, the two full-page colour plates of the Vogelkop tree-kangaroo *Dendrolagus ursinus* and the Grizzled tree-kangaroo *Dendrolagus inustus* together with some black-and-white plates, accompanied with the description of the species by Salomon MÜLLER published in a footnote.

66 MÜLLER 1857.

67 »Although all islands, from Java to New Guinea, share almost the same climate, and very many of them are rather close to each other, often only separated by narrow straits, each island of some extent possesses in larger or fewer number genera which are peculiar to it.« – Translation: M. G.; MÜLLER 1842, p. 252.

68 »It deserves to be mentioned that the larger Sunda islands possess many genera of mammals which are absent from the more eastward located Moluccan islands, whereas on the latter islands again some others occur that are lacking entirely on the former islands.« – Translation: M. G.; MÜLLER 1842, p. 252.

69 MÜLLER 1842, p. 289.

tion and study« [»eigener Anschauung und Untersuchung«]. It is noteworthy that MÜLLER explicitly remarked that he was giving the habitat and the distribution of the individual genera,[70] since in this respect most hitherto published zoological works contained many uncertainties and great confusion. From this it is evident that MÜLLER was fully aware of the enormous significance of geography in zoological studies, a quite remarkable fact prior to what would later become »WALLACE'S program« (see above).

Although MÜLLER'S 1842 paper alone would have granted him a prominent place in the annals of science especially as a mammologist, his subsequent paper written in October 1845 in Leiden, and published in the first volume of the then renowned German *Archiv für Naturgeschichte* in 1846, made him the first to create the biological discipline of *zoological geography*, thus rendering him one of the founding fathers of biogeographic research. MÜLLER in the title of his second paper in 1846 explicitly called this *a contribution to the zoological geography*, as would be done in 1860, more than a decade later, by Alfred Russel WALLACE (see below). In a later paragraph he also used the term *geographical zoology*.[71]

Following an introductory remark, MÜLLER suggested a clear biological separation within the Malay Archipelago,[72] stating: »Der indische Archipel zerfällt demnach in geographisch-naturhistorischer Hinsicht, der Länge nach in zwei Hälften von ungleicher räumlicher Ausdehnung. Die westliche grössere Hälfte umfasst die Inseln Borneo, Sumbawa, Java, Sumatra und die Halbinsel Malakka; die östliche Hälfte nur Inseln des zweiten und dritten Ranges, nämlich Celebes, Flores, Timor, Gilolo und etwa Mindanao in der äusseren Umgrenzung.«[73]

MÜLLER based the description of this general pattern not only on the distribution of mammals (which he primarily studies, though), but also included all then available information on the occurrences of particular species of birds, reptiles and amphibians (as later suggested but done only for mammals and birds by WALLACE, see below). In his paper MÜLLER recognized (*i*) a faunal separation between the Southeast Asiatic and the Australian mainlands, later to be known as »WALLACE'S line« separating the Oriental and Australian biogeographic regions, and (*ii*) a transitional zone between these major areas, later to be known and discussed as »Wallacea«.

(*i*) The geographic separation – or »die eigentlichen Scheidepunkte«, as he stated – starts to the east of Borneo with Celebes and Timor. According to MÜLLER, it is marked, for example, by the westernmost occurrence of marsupials and also the easternmost occurrences of monkeys (albeit only of the genera *Cercopithecus* and *Cynocephalus*), and with *Casuar* and *Megapodius* restricted to the eastern part, while peacocks (*Pavo*) and woodpeckers only occur on the large Sunda Islands. Thus, in contrast to the biota of the east, that of the western part is predominantly comprised of forms from the Asian mainland. For example, the tiger (*Felis tigris*) occurs on Java and Sumatra but is entirely lacking further east (MÜLLER apparently was unaware of the tiger, today extinct, on Bali).

70 MÜLLER 1842, p. 289.

71 MÜLLER 1846, p. 119.

72 MÜLLER 1846, pp. 109–110.

73 »The Indian Archipelago therefore is divided along its length in respect to geography and natural history into two parts of unequal spatial extent. The western larger half comprises the islands of Borneo, Sumbawa, Java, Sumatra and the peninsula of Malacca; the eastern half only islands of second and third rank, namely Celebes, Flores, Timor, Gilolo and maybe Mindanao as the outer boundary.« – Translation: M. G.

(*ii*) The transitional zone he found to be on the islands of Celebes, Flores, Timor and Buru, recognizing the fauna and flora of the Spice Islands or Moluccas as being already predominantly Australian with the marsupials as the most characteristic elements, among them members of *Phalanger*. »Diesen Übergangsstrich bilden die Inseln Celebes, Flores, Timor und Buru; er liegt also zwischen dem 136 und 145 Meridian-Grade östlich von Ferro«,[74] making especially the Moluccas in terms of their zoology most closely related to New Guinea and »New Holland«.[75] As another most typical faunal element he considered the *Babirussa* endemic to Sulawesi.

In addition to the examples among the mammalian taxa and their distributions across the archipelago that he provided, MÜLLER in the first quantitative approach also summarized that about 175 mammalian taxa are known altogether from the Malay Archipelago, including the Malaccan Peninsula and New Guinea. While 50 species – mainly the largely mobile chiroptera – occur over the entire region, he stated that less than 30 live exclusively in the eastern part.[76] In another example, MÜLLER noted for the woodpeckers that 16 species occur on Java, Sumatra, and Borneo while on Celebes there is only one species (*Picus fulvus)* and Picidae are entirely lacking on Timor and the Moluccas.[77] He summarized that among the reptiles there are 70 to 80 species that live in the eastern part of the Malay Archipelago including New Guinea, Celebes and Timor, whereas about 120 species occur in the western part.

Finally in a concluding remark, MÜLLER outlined the heuristic value of field research in the Indonesian Archipelago, stating that numerous islands especially in the eastern part remained as *terrae incognitae*. »Man ersieht daraus, welch ungemein fruchtbares und interessantes Feld dieselbe [Weltgegend] der Naturforschung darbietet.«[78]

Analysing MÜLLER'S writings[79] it is beyond doubt that he – and not Alfred Russel WALLACE as generally believed – was first to discover the faunistic division between Asia and Australia. As testimony of their parallel and independent observations, MÜLLER amazingly states – even on a taxon-by-taxon basis – the same examples among the faunal elements that later were utilized by WALLACE to illustrate the same peculiar faunal distinction. I am unaware of any references to Salomon MÜLLER in WALLACE'S writings or that of most of his contemporaries discussed in the following section; and we should conclude, therefore, that WALLACE apparently had no knowledge of the work and publication of the former. However, STRESEMANN noted that WALLACE might have been stimulated by MÜLLER'S 1846 account, but failed to give any evidence for this assumption.[80]

Notwithstanding, the fact that MÜLLER published his main contributions to science in German and Dutch does not justify the now century long and virtually complete ignorance of his earlier and parallel discovery that dominates particularly the contemporary Anglosaxon literature. It is not an unusual but, nevertheless, astonishing fact that MÜLLER'S contribution has been completely forgotten, as is revealed in the vast majority of biological, biogeographical and biographical accounts. He has also been overlooked by historians of science; for example, any mention is missing from recent influential works on the history of biology.[81] I was unable to find – even in German literature – more than an occasional and marginal reference to him and his biogeographical contribution.[82] In addition, only MAYR (1944), SIMPSON (1977) and recently BRANDON-JONES (1998) and OOSTERZEE (1997)[83] briefly mention Salomon MÜLLER. For example, the latter author stated that »Muller [sic!] in 1846 defined a line based essentially on ecology«, devoting the remaining book to WALLACE and the discovery of »his« line.

74 MÜLLER 1846, p. 109.
75 MÜLLER 1846, p. 113.
76 MÜLLER 1846, p. 110.
77 MÜLLER 1846, p. 120.
78 MÜLLER 1846, p. 127.
79 MÜLLER 1842, 1846.
80 STRESEMANN 1951, pp. 204–205.

As in the latter book, WALLACE is not only credited and cited as being first to discover this faunal demarcation, but he is also generally considered as »father of biogeography«.[84] However, to the same degree that WALLACE shares with DARWIN the discovery of natural selection as the driving force of evolution, Salomon MÜLLER shares with WALLACE the discovery of a distinct faunal demarcation line and an intermediate zone with endemic elements in the Malay Archipelago as well as the founding of zoological geography as a biological discipline.

Alfred Russel Wallace and Wallace's Line

It was, nevertheless, WALLACE – and not MÜLLER – who opened the scientific world's eyes to its biological diversity after having travelled 14000 miles within the Malay Archipelago on some 60 to 70 separate journeys and sending back to England a total of over 125000 specimens.[85] The theories he worked out during and after his travels in the East Indies dwelled essentially on spatial relationships, the reason to consider WALLACE as being, fundamentally, a geographer. Consequently, geographical information was instrumental for WALLACE both for his biogeographical as well as evolutionary contributions to biology. In several seminal papers and books he developed innovations in the historical reconstructions of faunas and, thus, implemented *zoological geography* as a biological discipline within the framework of evolutionary theory.[86]

It is, as SMITH correctly stated,[87] usually little appreciated how strongly natural processes are constrained by the necessity of having to take place in a three-dimensional space, and WALLACE'S skill at spatial analysis is best illustrated by his contribution to the biogeography of the Australasian region. He first developed the greater picture of a fundamental faunal difference between the western and eastern islands of the Malay Archipelago in his landmark paper on the natural history of the Aru Islands, off the coast of New Guinea.[88] This paper re-

81 See for example MAYR 1982, JAHN, 1998.
82 For example, in the writings of FINSCH 1865, RENSCH 1936 and STRESEMANN 1939, 1951.
83 OOSTERZEE 1997, p. 34.
84 For example BROWN and LOMOLINO 1993, RABY 2001.
85 WALLACE 1869; see also RABY 1996, 2001.
86 The term *zoological geography* has been used both by MÜLLER 1846 and WALLACE 1860 in the titles of their respective papers. In addition, MÜLLER 1846, p. 119, also used *geographical zoology* when suggesting a research program to investigate the regional fauna of the East Indies. SMITH 1991, p. 218, in bis introductory remarks to WALLACE'S contribution to biogeography differentiated these two terms as the former trying an »bistorical reconstruction of faunas« while the latter looks into the »spatial aspects of phylogenies«. It is highly unlikely that, given the lack of any indication on evolutionary ideas, at least MÜLLER could have meant his terms in this latter sense.
87 SMITH 1991, p. 218.
88 WALLACE 1857.

presents his first major treatise on the method of biogeographical analysis and is in many respects the birth of the new approach to that subject.[89]

Describing his biological observations WALLACE noted that »this difference [of the faunas in the Malay Archipelago], it must be well marked, is not one of species, but of genera, families, and whole orders. Yet, it would be difficult to point out two countries more exactly resembling each other in climate and physical features«.[90] Not very much later WALLACE went on with a large-scale analysis of faunal patterns, writing on the »zoological geography« of the Malay Archipelago.[91] However, as often in his writing, he anticipated the main subject of this classical paper a year earlier in a letter to the ornithologist and editor of the journal *Isis*, Philip Lutley SCLATER (1829–1913), who published the letter the same year.[92] In concert with observations from his travelling and collecting animals specimens in the East Indies, his first contribution to a systematic regional biogeography was directly triggered by SCLATER'S (1858) paper on the geographical distribution of birds.

This paper by the latter author was highly influential for shaping WALLACE'S concept as to how and where to locate the precise boundary between the Asian and Australian biotas. According to SCLATER,[93] his system should reflect »the most natural primary divisions of the earth's surface, taking the amount of similarity or dissimilarity of organized life solely as our guide«. While coarse, SCLATER'S formal approach of schematically dividing the earth's terrestrial surface into six biogeographical regions was based on the distribution of birds (but mainly restricted to passerines due to believed lower dispersal abilities). It had a major impact on zoogeography and on biogeography in general.[94] This early approach was immersed in the long prevailing view of earth's stability in the form of fixed continents and permanent ocean basins and, thus, from today's perspective represents the so-called »classical-descriptive« era of biogeography (in contrast to the late 20th century »analytic-phylogenetic« era[95]).

Nevertheless, SCLATER'S scheme turned out to be of enormous heuristic value. WALLACE not only *perfectly agree*[d],[96] but also believed that the six zoological provinces »will be confirmed by every other department of zoology as well as by botany«. Commenting on the precise boundaries of the suggested regions, WALLACE here for the first time suggested his later famous line to delimit the Indian (= Oriental Region).[97] »Its south-eastern limits I draw between the islands of Bali and Lombok, and between Celebes and Borneo, and the Moluccas and the Philippines.« WALLACE, repeating that »the same division will hold good in every branch of Zoology«,[98] later marked out the precise limits of the two faunal regions in the Malay Archi-

89 SMITH 1991, p. 231.
90 WALLACE 1857, p. 479.
91 WALLACE 1860.
92 WALLACE 1859. An anthology of more than 100 separate and in the literature widely distributed shorter writings of A. R. WALLACE is compiled in SMITH 1991 with brief annotations and editorial intrusions to these publications. These shorter publications serve indeed as a guide to WALLACE'S thought as he often subsequently incorporated into his books material first published in his journal articles as is the case with the 1859 letter to SCLATER published first in *Isis* (see SMITH 1991, pp. 266–270).
93 SCLATER 1858, p. 130.
94 See, for example, BROWN and LOMOLINO 1998, pp. 24–25.
95 See GLAUBRECHT 2000.
96 WALLACE 1859, p. 449.
97 WALLACE 1859, p. 452.
98 WALLACE 1860, p. 172.

pelago by contrasting individual taxa. Despite his claim that the regional limit will be followed by most (if not all) groups of animals, he only discussed mammalia and birds. Therefore, WALLACE does not surpass the general approach presented 14 years earlier by MÜLLER for four vertebrate classes (see above). Albeit having more detailed knowledge on the distribution of individual taxa, the general claim that WALLACE »was the first person to analyze faunal regions based on the distribution of multiple groups of terrestrial animals«[99] ultimately does not hold true in two respects.[100]

It should be mentioned explicitly here, though, that WALLACE correctly drew his demarcation line that separates the Oriental and Australian fauna between Bali and Lombok and Borneo and Celebes.[101] In contrast, MÜLLER had assumed for the southern part that the faunal division should lay further east, i. e. east of Sumbawa, while he clearly saw the fundamental faunal difference between Borneo and Celebes.[102]

This distinct perception also has relevance in light of the question about the causation of this pronounced faunal division. While we do not have any indication that MÜLLER ever thought about it, or at least addressed this aspect, it is worthwhile to briefly examine the development of WALLACE'S thought on this matter. It is occassionally assumed that, although WALLACE'S line directly corresponds to deep water marking the limit of historical land connections among the major East Indian islands and between them and the Southeastern Asian mainland, WALLACE »did not realize this«.[103]

However, this is apparently only true for his earlier writings. Indeed, in his 1860 paper he stated that »there is nothing in the aspect or physical character of the islands to lead us to expect such a difference; their physical and geological differences do not coincide with the zoological differences. There is a striking homogeneity in the two halves of the Archipelago.«[104] In contrast, after his return to London in 1862 WALLACE increasingly thought about and argued for a parallel between faunal similarities and the continental extensions, i. e. shelves. It was Charles DARWIN, having communicated WALLACE'S 1860 paper to the Linnean Society in 1859, who in August 1859 mentioned in a letter to WALLACE (then still in Indonesia) a close relation between depth of water and the degree of biological affinity.[105] DARWIN cited a paper by George Windsor EARLE (1813–1865),[106] who travelled in the Indian archipelago between 1832–1834,[107] and published a paper on the physical structure and arrangement of the Indian Archipelago.[108] This paper is accompanied by a map showing the existence of shallow seas

99 BROWN and LOMOLINI 1998, p. 25.
100 Today it is known that far from all taxa show distributional boundaries corresponding precisely to WALLACE'S line; other lines have been described to accommodate them. For an overview and relevant literature see, for example, OOSTERZEE 1997. A recent discussion using limnic gastropods and references to additional literature is given in GLAUBRECHT 2000.
101 See, for example, his maps in WALLACE 1863, 1876.
102 MÜLLER 1846.
103 For example BROWN and LOMOLINO 1998, p. 308. For a recent account on the biogeography of the Indonesian Archipelago and possible underlaying palaeogeographical causations summarizing current knowledge see HALL and HOLLOWAY 1998.
104 WALLACE 1860, p. 175.
105 See for details FICHMAN 1977, p. 51; CAMERINI 1993, pp. 716–717.
106 As CAMERINI 1993, p. 716, pointed out, the spelling of EARL(E)'s name varied in his own publications and references to him by contemporary authors.
107 See EARLE 1837.
108 EARLE 1845.

between the Asiatic mainland and the larger Sunda Islands on the one hand and New Guinea and Australia on the other hand.[109] Later, WALLACE in his own paper on the physical geography addressed this important finding but argued vehemently against EARLE'S hypothesis of Australia being once part of Asia.[110]

The combination of his own biological observations with tbe increased geographic knowledge unfolding since around the mid 19th century that even allowed first hypotheses on causal explanations of zoogeographical patterns, eventually enabled WALLACE to more fully document and analyse the distribution of animals than anyone before him.[111] This is illustrated by his development of a detailed and very precise map of the earth's biogeographic regions[112] continued to be used today. Thus, although many of the concepts enunciated by WALLACE were introduced by earlier scientists, it was WALLACE – based on the available geographical experience – who then for the first time »restated, documented and interpreted them in an evolutionary context«.[113]

In the context of the development of evolutionary theory, CAMERINI has recently examined how maps were instruments of thought and as visual components of the conceptual framework.[114] Mapping faunal boundaries since WALLACE'S time served not only as a method for organizing and communicating faunistic data but was also a potential and increasingly powerful device in providing and compiling the data in support for modern evolutionary argumentation.

Interestingly, this approach has only been taken up again about half a century later by the pioneers of the modern or synthetic evolutionary theory as will be shown in a section further below, with the German-born Ernst MAYR playing a key role in this process precisely a century after MÜLLER.

Travelling Naturalists on New Guinea

With Alfred Russel WALLACE a gradual but highly significant change takes place over the course of the second half of the 19th century. As RABY pointed out,[115] for the new generation of individual scientific travellers, Alexander VON HUMBOLDT (1769–1859) and Aimé BONPLAND (1773–1858) with their journeys to South America, have served as a role model for many successors to come (less so for various reasons but also deserving mention, Maria Sibylla MERIAN and Charles de La CONDAMINE [1701–1774]). Not only have later naturalists themselves repeatedly referred to these earliest individual scientific travellers, but their function as a role model has also been stressed by many historians of science. For example, RABY gave an insightful account on the triumvirate of Amazonian naturalists, Henry Walter BATES (1825–1892), Alfred Russel WALLACE and Richard SPRUCE, who are representative of a second group of scientific explorers.[116] With Ida Laura PFEIFFER (1797–1860), Charles M. ALLEN (1823–1892) and Frederick SMITH (1805–1879), those naturalists and their assistants working in the Malay Archipelago next to WALLACE have been portrayed by BAKER.[117] A compilation of some of these scientific travellers in Australasia is given in Table 2.

Tab. 2 Scientific travellers to Australasia in the years 1833–1930, with focus on New Guinea – some examples (compiled from various sources)

1833–1835	Salomon MÜLLER travelled on Sumatra
1836–1837	Salomon MÜLLER travelled in South Borneo with L. HORNER and P. W. KORTHALS
1839–1848 and 1855–1864	Franz Wilhelm JUNGHUHN'S journeys on Java and Sumatra
1854–1862	Alfred Russel WALLACE'S journey through the Malay Archipelago
1859–1860	Andreas Feodor JAGOR in the Philippine Archipelago
1861–1865	H. A. BERNSTEIN'S journeys to the island archipelago of New Guinea
1862–1863	Eduard VON MARTENS' East Asian journey including Indonesian islands
1863–1865	Karl SEMPER on the Philippines
1863–1870	Hermann VON ROSENBERG on New Guinea
1872–1876	Odoardo BECCARI'S (botanist) and Luigi Maria D'ALBERTIS' first journey to New Guinea
1874–1877	Luigi Maria D'ALBERTIS in New Guinea
1875	Odoardo BECCARI'S second journey to New Guinea
1878–1884	Andrea GOLDIE (botanist collector) and Carl HUNSTEIN (adventurer)
1879–1882	Otto FINSCH'S first journey to the South Sea, incl. Australia's Cape York Peninsula, Torres Strait Islands, and south coast of New Guinea
1884–1885	Otto FINSCH'S second journey to the South Sea and New Guinea
1887	C. SCHRADER'S first German Sepik expedition (with HUNSTEIN)
1889	William MACGREGOR explores New Guinea
1891–1892	Richard SEMON'S journey to study monotrems, marsupials, and lung-fish in Australia with visit to New Guinea
1896	First German Ramu expedition; William MACGREGOR'S first crossing of New Guinea's SE Peninsula
1893–1896 and 1901–1903	Fritz SARASIN and Paul SARASIN explorations through Sulawesi (then Celebes)
1910–1912	Fritz SARASIN and Paul SARASIN on New Caledonia and Loyalty Islands
1910–1912	Erwin STRESEMANN'S expedition to the Moluccas
1927	Bernhard RENSCH'S expedition to the Sunda Islands
1928–1930	Ernst MAYR' expeditions to New Guinea and the South Sea

109 Interestingly, WALLACE apparently attended a meeting on 8 February 1853 of the Zoological Society in London, where EARL gave a note on the zoology of the Malay Peninsula (see RABY 2001, p. 86). In an earlier footnote EARL 1845, p. 363, referred to the fact – as »rather a singular circumstance« – that kangaroos, that were first in 1828 discovered in New Guinea, also occurred on the Aru Islands laying off the coast of this island and on the Australian shelf. SCLATER 1858, pp. 130, 131, has repeatedly referred in his account on the avifaunal regions to the physical atlases published not much earlier as an improved method to compile contemporary knowledge; see also CAMERINI 1993 for information on DARWIN.

110 WALLACE 1863. The details of WALLACE'S development in respect to the problem of land connections and differentiation of faunal regions are investigated by FICHMAN (1977).

111 WALLACE 1869, 1876.

112 WALLACE 1876.

113 BROWN and LOMOLINO 1998, p. 25.

114 CAMERINI 1993.

115 RABY 1996, p. 8.

116 RABY 1996.

117 BAKER 1995.

Most of these travelling naturalists, so characteristic for the second half of the 19th century, were not sponsored directly by the government, like HUXLEY or DARWIN attached to Royal Naval survey ships. They were not salaried, essentially independent and solitary, self-financed with mostly only additional support from either learned societies or institutions for which they work. They were »trading in beetles and birds and monkeys and dried plants who needed to collect extensively even to pay their expenses, let alone to secure a possible income for the future«. These members of a new species of freelance, self-financing collectors were truly »scientific entrepreneurs«, as RABY so aptly has named them,[118] and brought to attention the riches of the previously virtually unknown biota of the regions they explored. In addition, their journeys and works were highly influential and slowly helped – via their material and observations brought back to Europe as well as their reports and studies – to reshape the world of natural history.

For example, Franz Wilhelm JUNGHUHN (1809–1864) travelled between 1839 and 1848 and again between 1855 to 1864 on the Sunda Islands Java and Sumatra, on which he systematically studied geology and geography, vegetation and climate, thus following the path outlined only a few years earlier by MÜLLER. For the Philippine Islands – that archipelago WALLACE never reached despite earlier plans[119] – we should mention Andreas Fedor JAGOR (1817–1890) who travelled there as one of the first naturalists in the years 1859 and 1860. He was followed in 1863–1865 by Karl SEMPER (1832–1893). Celebes (today Sulawesi) was explored by the Swiss naturalist and ethnographer Fritz SARASIN (1859–1942) together with his cousin Paul SARASIN (1856–1929). They started traveling together in 1883 on a journey to Ceylon; Fritz SARASIN in 1910–1912 also explored New Caledonia and the Loyalty Islands.

From the plethora of travelers and their journeys all over the world, only very few can be mentioned here, and this should also be restricted to the region of New Guinea. Although having a long history of individual and scattered discoveries,[120] this island continent remained seldom visited through most of the 19th and far into the subsequent century (see Tab. 2). Given the close proximity to the heavily travelled Moluccas that attracted the attention of earlier maritime powers[121] this fact is remarkable even in light of New Guineas's history of discovery. To mention only one example, WALLACE (1869) during his eight years in Indonesia only spent about five months in 1858 near Dorey Harbour at the northwest coast of New Guinea, curiously enough at exactly the same time and location as the Dutch *Etna* expedition.[122]

In the late 19th century it was the Italian botanist Odoardo BECCARI (1843–1920), who in 1872–1876 and again in 1875 explored this large island and later published a travel account.[123] Among those explorers and adventurous naturalists who contributed to the knowledge of New Guinea's fauna and flora, thus ranking most prominently as being of extraordinary merit, are also Luigi D'ALBERTIS (who made natural history collections on New Guinea for Giacomo Marquis DORIA'S *Museo Civico di Storia Naturale* in Genoa), Michael Oldfield THOMAS from the Zoological Department at the British Museum in London (who, however, never visited the

118 RABY 1996, p. 79.
119 WALLACE 1869.
120 A single comprehensive account on the history of discovery in New Guinea is lacking, but several more or less extensive overviews can be found, for example, in MÜLLER 1857, FINSCH 1865, WICHMANN 1910, STRESEMANN 1954 and FRODIN and GRESSITT 1982.
121 cf. introductory remark in MÜLLER 1858, p. 264.
122 WALLACE 1869.
123 BECCARI 1924.

island but named about 2900 mammal genera, species and subspecies, among them about 2000 taxa from New Guinea)[124] and later George TATE from the American Museum of Natural History in New York (who carried out field work in conjunction with Richard ARCHBOLD).[125]

Mostly unknown, in contrast, are two German naturalists, who – at different times – also explored natural history on New Guinea, viz. Otto FINSCH (1839–1917) and Richard SEMON (1859 to 1918). Both were undoubtedly successful with respect to scientific output, albeit from different points of view.

The zoologist R. SEMON, who was a student of Ernst HAECKEL in Jena published, in addition to his famous scientific works on the biology, in particular the ontogeny and embryology, of monotremes, marsupials and lung-fishes, a travel report about his exploration in Australia, New Guinea and some Indonesian islands.[126] In contrast, the travels and scientific contributions of the ethnologist and zoologist Otto FINSCH from Bremen remained essentially obscure, not the least caused by the fact that only scattered reports were published in less known and less-widely distributed German journals, but especially due to the lack of a comprehensive scientific account and/or narrative given by the author himself. Apart from a compilation on New Guinea[127] and an annotated list of his writings,[128] his extensive journeys 1872–1882 and 1884–1885 to the South Sea, Australia and New Guinea and its circumstances are often forgotten today. Again, however, it was STRESEMANN who dedicated an entire chapter in his account on the history of ornithology to FINSCH and his contributions to the natural sciences.[129]

Nevertheless, both these travelling naturalists SEMON and FINSCH perfectly represent this second phase of the geographical »experience« of nature at the end of the 19th century. After the turn to the 20th century, this traveling tradition among German naturalists is continued, for example, with Erwin STRESEMANN'S Molucca expedition 1910–1912 and with Bernhard RENSCH'S Sunda expedition in 1927.[130]

Ernst Mayr and the »Geographical Principle«

Even more important for the genesis of the synthetic theory of evolution and the contribution of geographical experience are – at least from the systematist's point of view – the expeditions by Ernst MAYR (born 1904) to New Guinea and the South Sea during the years 1928–1930. The recognition of geography, in particular the geographical separation of taxa in the process of speciation, is today commonly accepted as being key to the contribution of naturalists toward the development of the evolutionary synthesis.

124 Michael THOMAS has been portrayed in FLANNERY et al. 1996, p. 6, as the »archetype of the old-fashioned museum curator, ensconced in the Mammal Department at the British Museum for almost four decades«. THOMAS was, with 1090 publications on mammals, certainly one of the most prolific taxonomists of all time. A biography and bibliography is given by HILL 1990.
125 For brief portrays see FLANNERY 1995.
126 SEMON 1896. Originally written in German, SEMON'S 1896 narrative has also been translated into English which contributed much to the fact that, next to his scientific contributions, his name is still around in the literature; see SEMON 1899.
127 FINSCH 1865.
128 FINSCH 1899.
129 STRESEMANN 1951, pp. 217–233.
130 These can only mentioned here; for more detailed accounts see, e. g. RENSCH 1930, HAFFER 1997, pp. 858–906; see also HAFFER et al. 2000 and HOSSFELD 1997, pp. 23– 47.

Although geographical isolation as an essential condition in the formation of species has been stressed as early as the second half of the 19th century, in particular by the German entomologist Moritz WAGNER,[131] it was largely ignored by many zoologists and evolutionary biologists over the following decades.[132] In the late 1930s MAYR realized how important the presentation of a massive documentation in favour of geographical speciation would be, given the then often prevailing Lamarckian views and in particular Richard GOLDSCHMIDT's thesis of systemic mutations and the ignorance of the importance of geographical speciation in the United States.[133] Therefore, according to his own account, he took a leading role in this process after having taken up the viewpoint of earlier workers in Germany, such as the entomologists Karl JORDAN and Moritz WAGNER and the ornithologists Ernst HARTERT and Erwin STRESEMANN, who all suggested that geographical separation plays the primary role among isolating factors. MAYR supported their basic tenet that there is no speciation without separation, ultimately leading to his well-known and seminal contributions.[134]

MAYR's strong claim of geographical separation, that forms the basis of his 1942 synthesis, undoubtedly also has its roots in his early field experiences in the South Sea. He combined those in the most fruitful way with the idea on geographical separation which was during this time, as MAYR stated »official philosophy in the bird department of the Berlin Museum«[135] where he had grown up. However, astonishingly there is not a single comprehensive account on his early and adventurous travels. MAYR only gave three published reports on the scientific results of his New Guinea trips[136] and one, very cursory account on the Solomon journey.[137] In the course of an ongoing effort by the present author to reconstruct the detailed itinerary from various sources (including MAYR'S publications, correspondence and museum collection notes), the exact route and dates of his journeys were compiled[138] in order to allow further research into the genesis of his thought about the importance of geography for evolution.

Early Beginnings in Germany

After having studied medicine in Greifswald since 1923, MAYR in February 1925 decided (on STRESEMANN'S recommendation) to study zoology at the *Friedrich-Wilhelm University* in Berlin (later to be named *Humboldt University*), where he – under the supervision of the renowned systematist and curator of ornithology at the Natural History Museum in Berlin, Erwin STRESEMANN (1889–1972) – completed a dissertation on the range expansion of the European serin finch *Serinus canaria*.[139] This already was a study with a clear systematic-zoogeographic focus. He had exactly 16 months to finish this PhD thesis, before he became assistant at the Berlin Natural History Museum on July 1, 1926. Although he was mostly absent on field research or later as

131 WAGNER 1868.
132 See for discussion, e. g. JORDAN 1905, MAYR 1980.
133 MAYR 1980, p. 420.
134 MAYR 1940, 1942.
135 MAYR 1980, p. 420.
136 MAYR 1930, 1931, 1932, supplemented with a short note by STRESEMANN 1929 and HARTERT 1930.
137 MAYR 1943.
138 Bases on this research, a large-scale map was assembled and presented during the 10th annual meeting of the *Deutsche Gesellschaft für Geschichte and Theorie der Biologie* at the Museum für Naturkunde of the Humboldt University in Berlin in June 2001; the detailed itinerary and a map will be publisbed elsewhere.
139 See MAYR 1926.

research associate in New York in 1931 and 1932, MAYR officially remained (albeit unpayed) in this position until the end of July 1932.[140]

As revealed by their extensive scientific correspondence,[141] it was under the influence of his teacher and friend STRESEMANN in Berlin that MAYR first became aware of the importance of reproductive isolation. STRESEMANN'S ideas and concepts strongly facilitated the development of his views of the species concept and speciation phenomena in the late 1920s and early 1930s.[142] In addition, it was Bernhard RENSCH (1900–1990) who also worked as curator at the Berlin museum and who's book on geographical races and the problem of species formation[143] was highly influential to MAYR when he read it in 1930 after returning from the Solomon Islands.[144]

Prior to his field work as naturalist, there had been no time to allow »for a minimum of thinking about such ›extraneous‹ matters as the mechanisms of evolution«, as MAYR later put it;[145] and »like Darwin we believed in a categorical difference between continuous and discontinuous variation«. However, and apparently even forgotten by Ernst MAYR himself, his geographical thinking has very early roots as revealed in a letter by him to Erwin STRESEMANN, dating from May 12, 1924.[146] A reproduction of a hand-drawn sketch by MAYR in the letter is provided in Figure 3.[147]

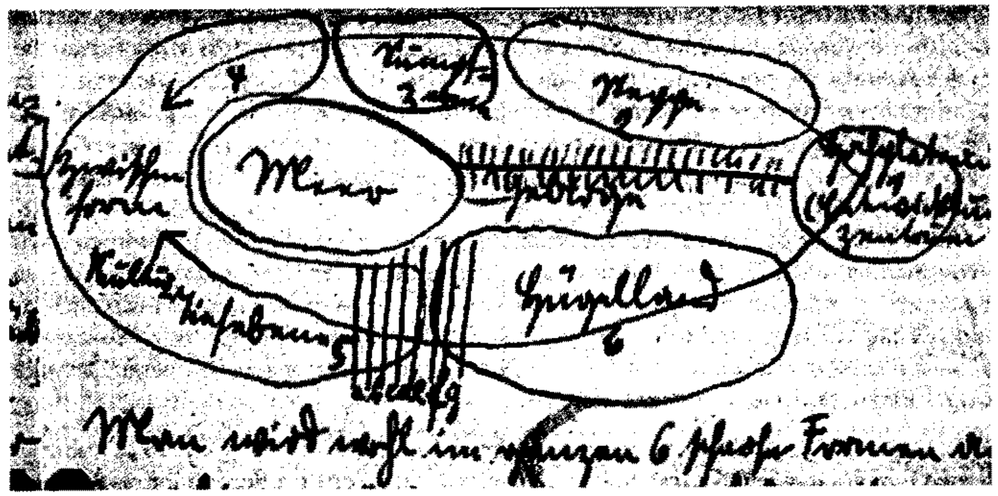

Fig. 3 Detail of a letter by Ernst MAYR to Erwin STRESEMANN, dating from May 12, 1924, with a hand-drawing illustrating his early ideas as to the formation of species and the role of geographical isolation in this process (from the *Handschriftenabteilung* of the *Staatsbibliothek Preußischer Kulturbesitz* in Berlin (Nachlass STRESEMANN; 150).

140 *Historische Schrift- und Bildgutsammlung Museum für Naturkunde* Berlin; see also LANDSBERG 1995, HAFFER 1995, 1997, pp. 62–100.
141 See HAFFER 1997.
142 See, e. g., MAYR 1980, pp. 414–415; 1982; BOCK 1994, HAFFER 1994, 1995, 1997, 1999, HAFFER et al. 2000.
143 RENSCH 1929.
144 MAYR 1980, p. 416, HAFFER 1997.
145 MAYR 1980, p. 413.
146 This letter is in the *Handschriftenabteilung* of the Berlin *Staatsbibliothek Preußischer Kulturbesitz* (Nachlass STRESEMANN; 150).
147 This letter and the sketch was published and re-printed by HAFFER 1994, p. 115, Abb. 1, and

As is illustrated, MAYR has anticipated the importance of geography in the struggle to solve systematic questions in the context of species concepts and speciation. He also suggested possible explanations and solutions depicting this ecologically based, historical-dynamic interpretation on the origin of geographical variation of species. HAFFER has extensively investigated this early development of MAYR's thinking showing that MAYR in 1924 has already outlined to STRESEMANN a research program that he would eventually conduct on his own.[148] Consequently, one can come to the conclusion that, already during his early Berlin years, it was clear to MAYR where naturalists would have to look for evidence and for examples to test their hypotheses.

Mayr's Expeditions to New Guinea and the Solomon Islands, 1928–1930

Far into the 20th century New Guinea has remained an enormeous, largely unexplored island continent.[149] During the International Congress of Zoology in Budapest in autumn 1927, Lord Walter ROTHSCHILD (1868–1937),[150] who then held the largest private collection of birds in the world at the Zoological Museum in Tring near London, and Dr. Leonard C. SANFORD (1868–1950), trustee of the American Museum of Natural History in New York, on STRESEMANN's initiative invited MAYR for a collecting expedition to northern New Guinea. In February 1928 MAYR left for the South Sea, and did not return until the end of April 1930. He was twenty-three years old then, had never been on an expedition before and was admittedly »inexperienced in bird collecting«.[151] Nevertheless, prior to his trip, he enthusiatically studied the bird fauna of New Guinea in the museum collections in Tring and Berlin to acquaint himself with the birds known from the island.

These journeys of Ernst MAYR have been referred to as »Rothschild-Expedition nach Niederländisch-Neu Guinea« (1928), as an »Expedition der Universität Berlin in das Mandatsgebiet Neu Guineas« (1928–1929) and as »Whitney-Expedition des American Museum of Natural History zu den Solomon Inseln« (1929–1930).[152] Although they were carried out in immediate succession, they had quite different sources of financing and, particularly the last, a different character.

(*i*) The journey to Dutch New Guinea (today Irian Jaya) from April to October 1928 was covered by a grant given by Lord ROTHSCHILD with the purpose of collecting for his museum in Tring and for the AMNH. Ernst MAYR only gave two brief narrative accounts on the first part of his travels, the trip to the Arfak and Wandammen Mountains in the Vogelkop Peninsula of NW New Guinea, and to the Cyclops Mountains, also in the Dutch New Guineas.[153]

HAFFER 1997, p. 409. However, the sketch there is re-drawn. In contrast, it is here shown as the original hand-drawn sketch by MAYR.

148 HAFFER 1994, pp. 114–119; 1997, pp. 64–68.

149 For field biologists New Guinea still is a biological treasure trough par excellence; for a recent account on the biogeoraphy and ecology of the biota of New Guinea see, e. g. GRESSITT 1982. The same holds true for the archipelago of the Solomon Islands, still one of the most remote and biologically undiscovered regions. Only until recently, with the monograph of MAYR and DIAMOND 2001, this has started to change, at least for the avifauna.

150 A biography can be found in ROTHSCHILD 1983.

151 MAYR 1930, p. 20.

152 See e. g. JAHN 1998, p. 898.

153 MAYR 1930, 1932, HARTERT 1930.

(*ii*) The subsequent voyage to the former German Mandated New Guinea (today in Papua New Guinea) from October 1928 to June 1929 was supported by a grant from the German *Forschungsgemeinschaft der Deutschen Wissenschaft*. MAYR explored the Saruwaged Mountains and Herzog Mountains; the material from there was for the Berlin Museum.[154]

(*iii*) Finally, the expedition to the Solomon Islands from July 1929 to February 1930 was financed as part of the *Whitney South Sea Expedition*. This latter journey was originally not planned by MAYR; it only turned out in May 1929 as a welcome opportunity while he was collecting in the Herzog Mountains at the northeast coast of New Guinea. This expedition was part of a long-term venture financed by Harry Payne WHITNEY (1872–1930) from New York, who thus enabled systematic bird collecting trips during the 1920s and until 1939 on all islands of the South Sea.[155] For this Solomon Islands trip we only have a cursory narrative but should note here that MAYR participated in the collecting of birds on the three previously poorly or unexplored islands of Choiseul, Malaita and San Cristobal.[156]

Case Studies from Birds

Initially, MAYR was especially interested in the bird forms of the different mountainous regions on northern New Guinea. During his expeditions he visited five of these ranges, three of them are in todays Irian Jaya (i.e. Arfak, Wandammen, and Cyclop Mountains), the other two (the Saruwaged and Herzog Mountains) are in Papua New Guinea. The scientific results including the description of new bird species and subspecies have been published between 1931 and 1945 in a series of about 20 papers, contributing to the other results of the *Whitney South Sea Expedition*. A first summarizing account on the systematics and distribution of birds from Polynesia was published in German,[157] followed by a fieldguide on the birds of the Southwest Pacific.[158]

However, beyond doubt the most important outcome of MAYR's geographical experience in the South Sea was the two accounts on speciation in birds and on the evolution and the origin of species;[159] these are mainly based on examples from the birds and geographical data he compiled during his early travels, thus during the »scientific work that takes us into the field«.[160]

What was the Galapagos for Charles DARWIN and the Aru Islands for Alfred Russel WALLACE, New Guinea and the Solomon Islands would become for Ernst MAYR, perhaps with the significant difference that the latter was well prepared to discover the many zoogeographical examples and their suitability to serve as evolutionary biology model cases in the field. Owing to their spatial separation and, correlated with this, the rapid evolutionary changes observable, insular habitats – either on isolated mountain ranges or on oceanic islands in particular in an archipelago setting – provide natural laboratories for zoological studies. MAYR has illustrated and discussed many of these examples among the bird fauna of Oceania and New Guinea, as for example those from birds of paradise (*Paradisaea*) on New Guinea and some adjacent islands, or from the whistlers or »thickheads« (*Pachycephala pectoralis*).[161] HAFFER has again

154 MAYR 1931, pp. 639, 640; MAYR 1932.

155 See details in BOCK 1994, pp. 274–276.

156 MAYR 1943.

157 MAYR 1933.

158 MAYR 1945.

159 MAYR 1940, 1942.

160 MAYR 1932.

161 MAYR 1942.

examined some of these case studies in the light of MAYR's contribution toward the evolutionary synthesis in the late 1930s and 1940.[162] General evaluations of MAYR's scientific contributions based on his geographical experience have been repeatedly presented recently initiating quite an industry following MAYR's 90th birthday.[163] Thus, we can only conclude here that his experience and roots as a travelling naturalist as well as systematist and zoogeographer eventually placed him in a prominent position for his synthetic accounts on the concept of species and on geographically induced mechanisms involved in speciation. His and others detailed research on the spatial occurrence of faunal elements and the geographical variation *in situ* provided the key for our present biogeographical and evolutionary biology knowledge, including such phenomena as natural selection, faunal regions and their delineation, endemisms and radiations, *formenkreise* and superspecies, as well as the principle of peripheral isolates and the concept of allopatric speciation.

The Importance of the Geographical Factor

Despite a long tradition in exploration and even during the »golden age« of natural scientific expeditions, biogeographical experience and information has long remained a deficiency. Nevertheless, as I tried to show above, with RUMPF's (1705) epic work *»Rariteitkamer«* we see some very early approaches, often and long overlooked. Only with what is described here as »WALLACE'S program« the significance of spatial pattern and how these changed over time became paramount. The idea of travelling to gather facts about living animals and the idea of using these facts alone to build a theory about the living world has simply not entered the mind of many scientists prior to naturalists such as DARWIN and WALLACE.

One major result of WALLACE's but also of MÜLLER's earlier exploration for example in the Malay Archipelago was the clarification of zoological geography, in this case the discovery commemorated by the description »WALLACE'S line« and »Wallacea«. Their foundation of biogeography by carefully observing and noting the local occurrence and distribution in particular of animals rendered the geographic factor instrumental in providing the basis for the genesis of evolutionary theory only later taken up as key elements by the naturalists of the STRESEMANN circle with RENSCH and MAYR. Thus, the geographical »experience« – in both senses of the word – became paramount and should be regarded as one of the most significant contributions of naturalists toward the modern synthetic theory of evolution.

Within the framework of modern phylogeography this core research area in systematic biology has not lost any of its relevance for the formulation and testing of zoological and evolutionary hypotheses, as can be seen in the often very inadequate documentation of exact geographic origin of samples used for »modern« molecular genetic and phylogeographic studies.

Caveats

This important and influential contribution of travelling naturalists – and with it the significance of the determination of the precise geographical origin of specimens and, thus, the spatial distribution and dimension of species – has fallen into oblivion, not only among historians

162 HAFFER 1997, pp. 74–85

163 For example in BOCK 1994, HAFFER 1995, 1997; in addition see also COYNE 1994, FUTUYMA 1994, SMOCOVITIS 1994, HULL 1994, BEURTON 1995, JUNKER 1995, 1996.

of science but also among zoologists. However, it is not only from an historical perspective that the geographical factor is most relevant even for modern evolutionary biological studies, as science judges on theories and contributions by earlier authors on the grounds of their relevance and heuristic value for current studies and present knowledge.

Considering recent developments, including molecular genetic techniques in phylogeographic studies,[164] as a systematist one should be highly concerned with the ignorance of »WALLACE'S principle«, i. e. to precisely determine the geographical origin of each specimen under study. This is illustrated, to use only one example from one of WALLACE'S favourite animals of the Malay Archipelago, by recent molecular genetic studies as to the question about the number of species of orangutan on Borneo and Sumatra.

According to common knowledge, only one species *Pongo pygmaeus* occurs in Southeast Asia, with two subspecies living on the islands of Borneo (*P. p. pygmaeus*) and on Sumatra (*P. p. abelii*). Molecular genetists repeatedly reached the conclusion that there might be more than this one species, postulating distinct species status for each of the separate island populations on Borneo and Sumatra.[165] However, the same authors admitted in their papers that, unfortunately, they were not able to control for the geographical origin of the specimens they studied. Consequently, these papers were quickly criticized not only for having sampled only a single specimen each, but also for having taken DNA samples from zoo animals for which the precise origin was indeed unknown.[166] Thus, although it remained unsolved whether the animals for which separate species status was suggested came from either Sumatra or Borneo, these molecular papers made it successfully through the peer-review process and were published in renowned international scientific journals. Finally, this debate ended with the suggestion that for those studies the precise locations should be given and the deposited specimen samples made generally accessible.[167]

Conclusion

With this proposal, eventually molecular geneticists advance to a procedure that became a corner stone of the practice of so-called »classical« biosystematists since the scientific travels of naturalists in the 19th century. Thus, now the most modern discipline in biology also joins this long and important tradition in zoology. This fact lends further proof to the proposition that WALLACE'S *geographical principle* – the historical development of which was outlined in the present paper – has lost nothing of its paramount importance for the formulation of zoological and evolutionary biological hypotheses.

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164 For an overview see, e. g., AVISE 2000.

165 XU and ARNASON 1996, MUIR et al. 1998, 2000.

166 For example RUEDAS et al. 2000.

167 For example, RUEDAS et al. 2000, p. 131, seriously recommended that »papers addressing the phylogenetic relationships [...] should contain a ›specimens examined‹ section explicitly detailing the material examined, [...] [which] should include exact location of geographic origin of specimen (i. e. precise collecting locality)«.

made them available for the reconstruction of a detailed itinerary of his travels in New Guinea and the Solomon Islands in which also Katja PETERS helped. I am thankful to Hannelore LANDSBERG for providing documents in the Berlin Natural History Museum archives, to Jürgen HAFFER for discussions and, as well as Ernst MAYR, for many valuable comments on and annotations to the manuscript, to Ellen STRONG for linguistical help with the English and to Uwe HOSSFELD for his encouragement.

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