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50 years teaching and research in palynology at the University of Amsterdam

Palynologists at the University of Amsterdam celebrate the 50th anniversary of their research group, an important landmark in teaching and research. In 1966 palynology became part of the biology curriculum and over the years it has made its mark in international research.

In 1951 Thomas van der Hammen moved to Colombia after he had completed his PhD at the University of Leiden. He trained young Colombian geologists at the Colombian Geological Survey in Bogotá, many of them later reached key positions in applied geological research. Van der Hammen's work was pioneering. He developed a palynological nomenclature, built a pollen collection of holotypes, contributed to commercial exploration of minerals, and discovered the immense potential of the deep north Andean sedimentary basins. Thomas married the Colombian Anita Malo-Rojas and Colombia became his second homeland. At the end of the 1950s the family Van der Hammen moved to The Netherlands. He became a researcher at the Geological Institute in Leiden.

Field course: After Van der Hammen moved to Amsterdam he initiated together with Lex Wilmstra studies on the late Pleistocene landscape development in Twente, using geology, palynology, botany, geomorphology and sedimentology. This central eastern part of The Netherlands is well known for the hilly landscape, formed by ice pushed ridges of Saalian age reaching some 65 m above sea level. The landscape shows wind blown coversands, mosaics of vegetation related to nutrient status, current and ancient rivers patterns, and human impact on the landscape. In 1966 Van der Hammen and Wilmstra started a two weeks student field course based on their extensive field experience. Over the years more than 1000 students have been educated in 'reading the landscape' in a geological-palaeoecological perspective. The course was first taught by Thomas van der Hammen and Lex Wilmstra, since the 1980s by Bas van Geel and Henry Hooghiemstra, and in recent years Stefan Engels replaced Bas van Geel. Last year William Gosling and Crystal McMichael became the new course coordinators.

Scientific exploration: The Amsterdam palaeoecology group explored palaeoecology from different viewpoints, such as: palynological-archaeological studies in the Tequendama Rockshelters near Bogotá (Van der Hammen), the significance of non-pollen palynomorphs (Van Geel), long continental records (Hooghiemstra), isotope palaeoecology (Dupont), vegetation-pollen rain relationships (Grabandt), a new chronological method based on pollen density dating (Middeldorp), the ecology of hummock-hollow bogs (Van der Molen), mass spectrometric study of peatified organic material (Van der Heijden), quantitative paleoecology (Witte), and Tertiary palynology (Wilmstra, Lorente, Sarmiento, Hoorn). A second research line focused on geobotanical inventory studies of selected ecosystems, such as the páramo (Cleef), montane forest (Van der Hammen, Cleef), canopy epiphytes (Wolf), tropical rainforest (Duivenvoorden), and inundated lowland forests (Urrego). As this paper has been written for 'Palynos' mainly palaeoecological aspects are highlighted here.

Geoecology: By integrating palaeoecology and vegetation inventory studies Van der Hammen belonged to the early geo-ecologists. Relationships between the biotic and abiotic worlds were most intensively studied in transect studies in the Colombian Andes, but also taught in the Dutch Nature Reserve 'Molenvan' during the student field course. Colombian transects were studied by PhD students Melief, Salomons and Kuhry. Van der Hammen's book series '*Studies on Tropical Andean Ecosystems*' (7 volumes: 1983-2008) reflects an account of the altitudinal distribution of vegetation, fauna, flora, soils and climate. For many years Wijmstra focussed on the analysis of the 195-m deep Greek Tenaghi Philippon core reflecting more than a million years of vegetation and climate history. Later Wijmstra's activities turned to the use of computers in palaeoecology. He supervised the PhD projects of Middeldorp, Witte and Lorente. Bas van Geel developed the use of non-pollen palynomorphs (NPPs) in pollen analysis. In addition he is an advocate for the possible role of solar forcing on climate change, studied in the PhD projects of Speranza and Blaauw. Bas also focussed on the famous 2800 yr BP climate event that caused significant environmental change on a global scale, for example permitting the horse-riding Scythians to expand from the Central Asian steppe westwards into the Balkan. Bas also published much on the life conditions of the mammoth during the latest Pleistocene.

A new forest: After his retirement in 1989 Van der Hammen moved to Colombia where he lived near Chia, a village some 15 km from Bogotá. His days were filled with paper writing, excursions, and discussions with students, researchers, governmental officials, mayors from surrounding villages, and even ministers on scientific issues and how to implement scientific results into society. Next to his house he turned a 3 ha maize-field around into a forest by planting 30,000 juvenile trees. The proportion of arboreal taxa in the pollen diagrams of the high plain of Bogotá was his guide. In doing this he re-introduced the 'high plain forest', a forest type that had been lost due to human intervention. His 'forest' attracted the attention of officials, nature conservationists and the media.

Deep continental pollen records: Two years after Van der Hammen retired in June 1991 Henry Hooghiemstra took over the leadership. Based on his Christiaan & Constantijn Huygens grant from the Netherlands Science Foundation NWO, he had cored the full sediment infill of the Bogotá basin. Improving the chronology of this deep sediment sequence was difficult: Paul Andriessen (Vrije Universiteit Amsterdam), Nick Shackleton (Cambridge), André Berger and Jean-Luc Mélice (Louvain-la-Neuve) all contributed to make incremental steps forwards. Almost 30 years after the initial chronology Lucas Lourens (Utrecht University) developed the final age model: the basin sediments reached 2.25 Ma in age.

Overarching projects: Work on long continental pollen records requires much patience, and other focal points in research were developed in parallel. In the frame of the 1995-1998 postdoc project of Hermann Behling (now at Göttingen University) rain forest in Amazonia and Chocó, savannas, and the dry intra-Andean valleys, were explored in three expeditions in 1997 and 1998. Sediment cores from some 25 sites were analysed by Behling, Berrio, Wille, and Vélez. These new data were used in the 1999-2002 postdoc project of Rob Marchant (now at York University) with focus on the biomisation of Latin American pollen records. The aim was to move from single-site studies in the temporal domain to multiple-site studies in the spatial domain. This synthesis allowed palaeodata-model comparisons and we realised as never before the variability in climate conditions over short distances in the Andes. In the temperate area postdocs Mauquoy, Yeloff and Bos worked with Bas van Geel on non-pollen palynomorphs, European vegetation and climate history, and solar forcing of climate change. Bas van Geel developed a joint project between The Netherlands and Russia. We collected sediment cores in southern Siberia to study Holocene environmental and climatic change that triggered a.o. the Skytian horse riding people to move westward.

Latin American Pollen Database: An important by-product of Marchant's biomisation project was the Latin American Pollen Database (LAPD), earlier initiated by Vera Markgraf. However, after the biomisation project had been closed in 2002 the LAPD missed the necessary support to keep the database updated. In her PhD project a decade later Flantua re-visited in her PhD project the entombed database and made a start with spatial analyses. Surprisingly enough we found in the literature over 1300 pollen records from virtually all Latin American countries. Now we are finishing first studies on Pleistocene connectivity dynamics to better understand north Andean distribution patterns.

Upper forest line in a deforested landscape: In the late 1990s Cleef and Hooghiemstra were often surprised to see in the northern Andes so many plantations of Mexican pine up to almost 3900 m. There, we expected páramo vegetation and we assumed this was a bad practice of 'green thinking' western countries. After two explorative trips in northern and central Ecuador we selected El Angel Reserve to study upper forest line dynamics. We developed a novel combination of proxies: vegetation analysis, ¹⁴C dating, fossil pollen, and molecular biomarkers preserved in peat cores and soil monoliths to study past positions of the UFL. It became evident that the natural UFL lies at 3650 m and we concluded that all afforestation projects above 3650 m were discreditable, and are destroying the biodiverse páramo.

New-generation pollen records: Around the turn of the millennium Hooghiemstra wondered how close can palynologists reach the stunning detail of ice core records. For a 5 years period we received funding for 2 PhDs and 1 postdoc. Two 58-m long sediment cores from Lake Fúquene were used to build a composite record including records for pollen, sediment fractions, and geochemistry. Postdoc Berrío built a team of young palynologists in Bogotá and there some 2000 of the almost 5500 pollen samples were analysed. Lucas Lourens from Utrecht University developed the age model, showing the record reflected the period from 284,000 to 27,000 yr BP. It appeared that the well-known millennium-scale climate variability extended from the last glacial into the previous glacial-interglacial couplet.

Fuelled by IPCC discussions, we realised that no good record of Holocene climate change existed. González-Carranza developed a pollen record reflecting the last 14,000 years in steps of 25 years showing much new evidence on extrinsic climate driven regional environmental change and intrinsic species competition within the forest. Most fascinating was the observation that subpáramo vegetation was repeatedly temporarily lost in the competition between forest and páramo.

Origin of Amazonian diversity: For decades the paleogeography of Amazonia was an important research theme. In her PhD thesis Carina Hoorn had studied Amazonian paleogeography since Miocene times culminating in the 1996-synthesis study in 'Geology'. After Carina had raised her family while living for periods in Oman, UK and Lybia she came 'scientifically' back with the 2008-Scientific American paper on the age of the Amazon River. Hoorn and Wesselingh edited the impressive 2010-book "*Amazonia: landscape and species evolution*". This book provided new ideas on the origin of Amazonian biodiversity, leading to the 2010-Science paper that combined evidence from geology, soils, vegetation, and molecular phylogenies. Carina showed that most Amazonian biodiversity originated during Miocene times, not during the Pleistocene. This made Haffer's forest refuge hypothesis (1969) obsolete.

Mauritius and the dodo: In 2008 Amsterdam palynologists started research in Indian Ocean island of Mauritius. Sediment cores from a volcano crater, lake infills and peat sections were analysed by PhD student Erik de Boer. We obtained records of vegetation and climate change since the last ice age showing an unknown sequence of forest turnover at the Lateglacial-Holocene transition: it looked as if nature had done experiments to find a new balance. The intriguing question why some hundred thousand giant turtoises and dodo's had died in a coastal swamp had become uncovered: droughts around 4200

yr BP caused drinking water to become brackish and so heavily contaminated with excrements that blooms of toxic cyanobacteria developed into a deadly cocktail.

Summarising the past 50 years: Several conditions favoured much our profile over the years. With respect to Colombia it are: the rich sedimentary basins in the Colombian Andes, the close collaboration with many representatives from the Colombian society, the variety of tropical ecosystems ranging from desert to rainforest and from lowlands to the perennial snowline, and the interest of so many Colombian students to complete a PhD study in Amsterdam. Further, the combination of research in temperate and tropical parts of the world, the close connection with teaching programmes in biology and earth sciences triggering a flow of students with a variety of backgrounds, the combination of studies on vegetation ecology and palaeoecology, successful acquisition of research grants, the presence of a permanent laboratory technician allowing the analysis of large numbers of pollen samples, and the variety of exciting research questions with relevance for science, society and industry. Between 1967 and 2015 in total 72 PhD students prepared their PhD thesis in the group, of which 31 came from abroad. Colombia had the largest contingent of 18 PhDs. Bas van Geel retired November 2012 and Stefan Engels temporarily took his responsibilities for teaching and management. Henry Hooghiemstra retired in November 2013 but continued teaching for another year. William Gosling was appointed in September 2014 as the new leader of the group. Crystal McMichael was appointed June 2015 as associate professor. We thank the University of Amsterdam for continuing this well rooted research line. A new team of palaeoecologists has already stated to lead the group into the future with much enthusiasm.

Research group Paleoecology and Landscape-ecology, Institute for Biodiversity and Ecosystem Dynamics, University of Amsterdam, Science Park 904, 1018XH Amsterdam, The Netherlands, Corresponding author: Henry Hooghiemstra (E-mail: H.Hooghiemstra@uva.nl).