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3/2003 ▶ Of Aphids and Ants ▶ Caesar's Waterworks ▶ The Capercaillie and the Question of Survival ▶ When Gods Become Visible ▶ The Whole Extent of the Antarctic ▶ The Revival of a Great Library

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How to Measure a Continent

A modern satellite system provides geoscientists with precise information about the tectonic movements of the Antarctic continent. The data are collected on the ground, sometimes under harrowing weather conditions. Of special interest to scientists are changes in the uplift and subsidence of the Antarctic peninsula. The results of the repeatedly undertaken measurements are used for studies on climatic developments. **Page 5**

Of Pools, Ponds and Pipes

The Roman Emperor Hadrian devoted much of his time to the construction and improvement of public works. His own residence – the Villa Adriana – outside of Rome was also equipped with sophisticated systems of water supply. Archeologists are currently trying to reconstruct the complex arrangement of pipes and canals ensuring the water supply for the lavish baths and fountains which the villa was famous for. **Page 8**

Hunt for a Literary Treasure

Konrad Peutinger lived in 16th century Augsburg and was a contemporary of Luther. During his lifetime he set up one of the most important humanist libraries in Germany, containing unique works of Gutenberg and Calvin. Yet, his legacy could not be protected. Most of the collection was dispersed among booksellers and other libraries after his death. Now, an Augsburgbased research group is trying to recover this lost literary treasure. **Page 17**

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Ants Have a Sweet Tooth, Too

Over millions of years ants have developed a fascinating coexistence with various aphid species. While the ants provide protection from predators and parasites, the aphids produce honeydew, a sugary excretion, on which the ants feed (Page 21). Cover photo: Klaus Hoffmann

Impressum

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Research in Europe needs fresh momentum in order to become more competitive with the rest of the world. Europe competes with the leading scientific nations, the United States and Japan, but also with Asian regions in which the individual high-population countries like China and India alone have enormous future potential.

A few years ago, EU research commissioner Philippe Busquin introduced the concept of the European Research Area (ERA). This was a decisive contribution to clarifying the discussion on research policy in Europe. He made it clear that to establish a strong ERA requires an effort to overcome internal weaknesses which arise from the diversity and fragmentation of the states and systems. To a certain extent, the ERA transcends the state of political unification of Europe in that it increases the existing research potential both within Europe and in a global context.

I see the concretization and refinement of the idea of the European Research Area as a major challenge for both politicians and researchers. Politicians have set ambitious objectives with the resolutions of Lisbon (2000) and Barcelona (2002). By 2010, Europe is to become the most competitive and dynamic knowledge-based economy in the world and increase its research spending to three percent of GDP. The research system must now respond to this improvement in the general conditions with concrete proposals and initiatives.

One such initiative is the EURYI (European Young Investigator) Awards programme, which emerged from the discussions of the presidents and leaders of the national research organizations in Europe (the EUROHORCs, European Union Research Organisations Heads of Research Councils) on the question of how these organisations can contribute their own resources to the realisation of the ERA. In recent years, many organisations have developed funding programmes by which they can pursue a strategy of supporting the next generation of highly qualified scientists that goes beyond fellowships for young researchers. It is

a question of attracting as many young scientists and academics as possible for research and offering them excellent conditions under which to pursue it. One central thought, as expressed in the Emmy Noether Programme of the DFG, but also in comparable programmes at our partner organisations, is the possibility of creating an independent research unit as they return from a successful stay abroad. For the DFG, the Independent Junior Research Group has become the

under competitive conditions. It is often the major industrial nations that are no longer in a position to recruit the demand for researchers from their own educational and university systems. Barely half of the young researchers working in the United States today were born in that country.

Up to now, with the exception of the human resources programmes of the EU, the nations of Europe have fought the battle to retain their pool of young scientists and



core of its funding plan for young researchers. The opportunity to attain independence in research early on, meaning just a few years after earning one's doctorate, should increase the motivation for working in research and at the same time improve one's prospects for a successful career.

The effort to lure young researchers back from abroad makes the present situation quite clear: The competition for the best minds is an international one and is waged

academics separately. With the EURYI Awards programme, the major research organisations of most European countries are joining together and entering the global competitive arena on a common basis. Any young researcher who qualifies for the programme can submit a proposal for a EURYI Award within the ERA, or, more exactly, in one of the fourteen countries with at least one organisation taking part in the initial call for proposals.

What are the details of the programme, first announced in mid-September 2003? After a preparatory period of about one year, the representatives of 18 organisations from 14 countries signed a Memorandum of Understanding in May 2003, in which they agreed to provide 5.2 million euro (the DFG's share is 1.3 million euro) per year for five years in an initial call for proposals for the programme. It is thus a shared fund in which the sole criterion for participation is quality,

student level, as well as allowances for consumables and travel expenses. That means a cost of between 150,000 and 250,000 euro per award in all participating countries, on average about 200,000 euro. With the annual amount of 5.2 million euro, one can thus expect approximately 25 awards in the first round. Applicants must have an outstanding scientific track record. They should demonstrate the potential to be able to play a leading international role in their particular

During the review process and in the final selection phase, the participating organisations work together in a two-stage process with the European Science Foundation (ESF) in Strasbourg. The organisation in the destination country is responsible and accountable for the review process in the first stage according to its own procedure. Each participating organisation is entitled to a certain number of nominations for the second, common round, according to its financial involvement. The up to 25 winners are selected from the 134 possible nominations by a panel process and with the help of interviews, at least for the top candidates. Based on the careful time planning, it is expected that the first call for proposals will be successfully completed with such a result by mid-2004. Then the first EURYI independent junior research groups will start in autumn of next year. This will be an important milestone for promoting young researchers and excellence in academia and for cooperation within the European Research Area.

And it will not stop with the EURYI Awards. Discussions are presently underway for the formation of a European Research Council. The real problem of the ERA is twofold, the fact that the EU framework programme does not provide for investment in curiosity-driven research and the fragmentation of the ERA into many and diverse systems, leading to a decrease in competitiveness. It thus would make little sense to add yet another research council offering similar funding instruments as the existing councils. Instead, the available money (an amount of 2 billion euro/year is currently under discussion) should be used to invest in instruments which overcome the present weaknesses and lead to added value. The coming year (2004) will be decisive in this respect.

Prof. Ernst-Ludwig Winnacker
President of the Deutsche
Forschungsgemeinschaft

Prof. Ernst-Ludwig Winnacker

Momentum for Research in Europe

*On the road to becoming the most
dynamic knowledge-based economy in the world –
Increasing competition for the best minds*

and in which any type of "juste retour", or a proportional distribution of awards to the individual countries, is abandoned.

A EURYI Award consists of a combination of a fellowship and project funding, using the Independent Junior Research Group in the Emmy Noether Programme as a model. The funding thus encompasses the payment of the leadership position itself and providing two to three staff positions at the doctoral student or postdoctoral

field. There is no age limit. Instead, since the doctoral degree is earned at different ages in the different countries, postdoctoral research experience of at least two to ten years is required. In addition, a qualified invitation connected with the agreement of the respective institution to take on the independent junior research group for a period of five years holds particular importance. EURYI Awards can be given in any field of study, including the humanities.



Measurement campaign in a hostile environment: The ice station is normally cut off from the outside world and getting supplies is difficult. Boxes are used to protect the equipment against the cold and damp.

The Whole Extent of the Antarctic

A satellite navigation system is giving geoscientists precise information about the uplift and subsidence movements of the Antarctic continent





The researchers approach an observation station on the Ukrainian ice-breaker "Dranitsyn". Their work is often dangerous and strenuous, at low temperatures, with strong wind, rain or snow. The electronics in the GPS receivers are also extremely sensitive to these hostile conditions. The penguins the scientists encounter everywhere are well adapted to the weather conditions in Antarctica.

Twenty-four satellites orbiting the earth on six planes at a height of about 20,200 kilometres: This image is part of the United States satellite navigation system, which has been fully operational since 1995. It is now difficult to imagine navigating without the Global Positioning System, or GPS for short, a system which is nearly unaffected by the weather and which is available around the globe, around the clock and free of charge. Between 1995 and 1998, several German universities and research institutes joined forces in cooperation projects with the aim of using GPS to determine the coordinates and velocities of a network of observation points covering the entire Antarctic periphery. In order to achieve this scientific objective, several GPS measurement campaigns were carried out and analysed during the Antarctic summers. The velocities and directions of movements of the observation

sites on the Antarctic Peninsula, which has active volcanoes and is subject to earthquakes, were of particular geoscientific interest. This data enables conclusions to be drawn about current tectonic movements in this area. It was particularly important to carefully mark observation points in the Antarctic which would remain "stable" relative to the solid bedrock over a period of several decades. In order to guarantee this, metal bolts were drilled directly into the solid rock. When very small tectonic shifts of just a few millimetres have to be detected, it is crucially important that neither the rock nor the observation point changes as a result of weathering caused by extreme tempera-

ture fluctuations in direct or indirect sunlight or frost. Horizontal displacement rates – i.e. the velocity and direction of the movement – can now be derived as standard from GPS observations with a high level of precision and reliability. However, this is not yet valid for the determination of heights and vertical displacement rates, which are much more subject to various external and system-internal factors. This is where the project carried out by the Geodetic Institute of the University of Karlsruhe comes in, which focuses on the height component and aims at finding a suitable evaluation strategy to obtain height information as accurately as possible. This will allow to derive uplift and subsidence in the Antarctic Peninsula area from repeated measurements. Statements on height changes in the Antarctic region are of interest with respect to climatic development, especially in the context of the greenhouse effect and related parameters, for example the ice mass balance in the Antarctic.

The electromagnetic signals transmitted by the GPS satellites pass through the earth's atmosphere on their way to the receiver and experience refraction and propagation delays as a result of various atmospheric factors. Two important regions of the atmosphere can be distinguished: the electrically charged ionosphere and the neutral atmosphere, which incorporates both the troposphere, extending



from the earth's surface up to a height of about ten kilometres, and the stratosphere, which is above it and extends to a height of about fifty kilometres. As nearly all weather phenomena occur in the troposphere, it is logical to determine the propagation effects in the neutral atmosphere by means of meteorological parameters such as temperature, air pressure and humidity. The method used involves either registering representative meteorological parameters on a continuous basis simultaneously with the GPS measurements, or attempting to determine the propagation delays from the GPS observations themselves, based on fundamental meteorological assumptions. If the objective is to

derive very accurate heights from GPS data, then it must be attempted not only to eliminate other sources of error, but also to achieve the best possible approximation of the prevailing meteorological conditions in the electrically neutral atmosphere during the GPS measurements. However, as cost-effective recording of accurate, representative weather data in the vicinity of the GPS monitoring sites is hardly feasible, the usual approach involves modelling.

When GPS measurements are made in polar regions, no signals can be received around the local zenith of the monitoring site because of the configuration of the GPS satellite orbits. However, zenithal GPS signals would be desirable, as these signals have the lowest propagation delays and disturbances because of the shorter distance travelled through the earth's atmosphere. It is therefore



A container laboratory is home and office for twelve scientists. Here the data is first screened and evaluated. Some "visits" to a GPS antenna can have serious consequences. A gull ("skua") obstructs the signals, briefly interrupting data recording.

unavoidably necessary to include signals recorded close to the horizon in the evaluation. However, these weaker signals, which are not used for routine measurements, have significantly poorer characteristics, again requiring suitable modelling strategies when using this critical data basis. In order to study these and other issues, GPS measure-

ments were carried out at three stations in the northern region of the Antarctic Peninsula in January and February 2002. This involved recording the signals from all GPS satellites above the horizon every five seconds over 24 hour cycles for three weeks. With an average of eight satellites, this set-up produced a large amount of data per station per day and therefore a uniquely high resolution of GPS data for this part of the globe. Carrying out measurement campaigns in such a hostile environment requires both sophisticated logistics and extremely detailed planning. After all, Antarctic stations receive their supplies mainly by boat or by helicopter. The geodetic equipment used at each site included a GPS antenna and receiver, handheld controllers with memory cards for recorded data, as well as car batteries and chargers for the power supply. For the measurements themselves, the sometimes extreme climatic conditions in Antarctica posed the greatest difficulties. Particularly the electronics in the GPS receivers are extremely sensitive to these extreme meteoro-

logical conditions. The battery charge time is also significantly reduced. In order to guarantee an uninterrupted power supply for the entire duration of the GPS measurements, i.e. 24 hours a day, and to ensure sufficient planning reliability, various simulations were carried out in a climate chamber prior to the GPS measurement campaign. The data was recorded on special memory cards, with rapid card changes guaranteeing minimal data loss. This was important since the data recording had to be interrupted simultaneously at all monitoring sites to change the cards. This approach was necessary because the measurements recorded simultaneously at station pairs have to be combined in the evaluation process by calculating the differences between the respective observations. The advantage of this differencing technique is that it is possible to eliminate or mitigate the effects of some major sources of error in the observations, such as the receiver clock error, i.e. the time delay between the time scale of the GPS satellites and the receiver clock. After the recorded data had been tested for gross errors and outliers during the first step of the evaluation, the respective horizontal displacement rates of the observed sites were compared with the results of former projects. At the moment, various parameters which have a significant influence on the GPS evaluation are being examined in detail in order to obtain height estimates with the best possible precision and reliability. It has become evident that the time intervals between the GPS observations analysed play a more significant role than previously anticipated. After the modelling phase has been completed, the optimised evaluation procedures will be applied to the data of previous observation campaigns in order to derive new results concerning height changes on the Antarctic Peninsula.

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Caesar's Waterworks

Emperor Hadrian's spacious residence still makes an impression today. How the complex got its water supply is of interest to more than just archaeologists

About 25 kilometres east of Rome just outside Tivoli – called Tibur in ancient times – lies the Villa Adriana. This complex of originally enormous dimensions served as the residence of the Emperor Hadrian, who ruled from AD 117 to 138, with spacious living quarters, ceremonial rooms, porticoes and a theatre, grouped around columned courtyards and gardens. In addition to baths, the villa also features numerous other feats of hydraulic engineering such as reflecting pools, fountain and garden installations, fishponds and latrines.

But where the water came from that was needed to operate these installations, which are still yet to be completely excavated, how it was transported, controlled and used and then where it went has not yet been explained. As part of an interdisciplinary project, researchers from different fields and several countries are exploring these questions for the first time. The examination conducted in February 2003 at the ruin site has brought new findings to light: Approximately parallel to the Villa Adriana, which was built on a long elevation, at a distance of



The Villa Adriana near Tivoli is famous for its baths, reflecting pools, fountains and ponds. The “serapeum” for imperial receptions (at right in the background) awaits with sophisticated hydraulic installations. Many of the buildings of the Villa Adriana – model below – had running water installations.

just 1.2 kilometres, far above the level of the imperial residence, run four of the major ancient Roman aqueducts. Their names are famous: Aqua Anio Vetus, Aqua Marcia, Aqua Claudia and Aqua Anio Novus. The idea that the Villa Adriana was supplied with water from one of these channels has long been discussed, but never further pursued.

The remains of a masonry wall, which were found in the area of these aqueducts and which could have belonged to a forebay of a pressure line running from there to the Villa Adriana, offered an initial approach for study. After partially uncovering them, the remains of the wall, previously only visible above-ground, are revealed to be part of a rectangular structure whose internal length and width were exactly ten by twenty Roman feet (one foot equals 29.6 centimetres). As evidence that it must have originally been a water tank, the plaster is of waterproof mortar and the beads are of the same material both in the corners of the building and the transitions from the sides to the bottom. These beads are sealing elements, which were state of the art for engineering Roman water structures.

Near the bottom of the head wall on the valley side there is also a teardrop-shaped wall culvert of seven centimetres diameter. Chemical tests clearly show that lead ions have bonded with the mortar. A lead pipe was apparently fed through the wall at this point. When uncovered to its foundation, it was also revealed that the wall, at 60 centimetres (two Roman feet) unusually thick (house walls were generally one and a half Roman feet thick), had an additional shell in front of it in the opus reticulatum

type of masonry typical of the Roman Empire. This has been almost entirely demolished. The original wall thickness was thus 90 centimetres altogether (three Roman feet). The same wall thickness has been determined on the slope-side opposite this, whilst the two long walls could not be uncovered far enough to state their original dimensions with certainty.

There is therefore no doubt that this structure was designed and built as a water tank. However, because no traces of calc-sinter, i.e., lime deposits, were found on the uncovered interior surfaces, the question as to whether the structure was actually used as a water tank must remain open for the present. In any case, it was used for a different function in a second phase, as decorated plaster fragments were found inside and outside the tank during excavation and likewise on the partially uncovered inside wall of the slope-side. Two large openings in the wall also speak for a subsequent change in function: One opening in the valley-side wall could indicate that large lead pipes of a pressure line





led from the tank to the Villa Adriana. On the other side, this 180 centimetre wide wall opening has an "even" dimension of six Roman feet (with a total wall length of ten Roman feet), which rather speaks against an accidental break caused by the violent removal of lead pipes. Another opening in one of the long walls appears to have been carefully made with nearly perpendicular faces. Its width of 105 centimetres is a typical dimension for door openings in houses of that period.

It therefore appears possible that the structure, originally conceived as a tank, took on a different function at some now-indeterminate point in time, perhaps as living quarters, after it was provided with a window on the valley side and, just around the corner, with a door in the long wall, as well as decorated on the inside.

A short distance from the slope-side wall runs another wall on the ground above, which proved to be a vault of the Aqua Marcia. In the course of examining the site, a largely destroyed but still clearly identifiable bottom of a small channel was revealed in the area be-

tween the tank and this aqueduct, with sides that can be discerned to some extent. This channel bottom runs towards the north-east corner of the tank. Because the tank wall itself is destroyed from this level, it cannot be clearly determined whether the channel opened into the tank or whether it was intersected by the construction of the wall and thus made non-functional.

This channel has been completely destroyed, leaving no remains, immediately in front of the Aqua Marcia. A depression was uncovered here, filled with soil and rubble, which could have belonged to a small pool. A more precise examination revealed that this small channel had a predecessor located below it, with an even smaller cross section, which is almost completely blocked with lime deposits, and forms the foundation of the higher channel. Because it was covered over by the later channel, it was not possible to determine where it led. It became clear, however, that it must have ceased operation by the time either the later channel or the tank was constructed.

How were the great baths (above) and the other fountains and pools supplied with water? The water pipe system of the Villa Adriana was complex and raises many questions. Right: A cross section through two diversion channels shows the newer, above, and, below, the older one with a smaller diameter. Excavations reveal a triangular outlet opening from Aqua Marcia with a small tank to slow down the flow of water.

Roman aqueduct channels were generally passable on foot for maintenance purposes, but the water level was comparatively low. At an accessible point of the Aqua Marcia above the area being examined, it was found that the man-high line is completely blocked with lime, possibly due to artificial measures. The reason for this soon became clear: Very high in the vault of the valley-side face of the Aqua Marcia there is a triangular opening, filled with calc-sinter on the inner side, whereas on the outer side a hole approximately 20 cm in depth remains. The exterior of the masonry is also covered with a layer of lime deposit,

even above the opening. The water in the channel was apparently under pressure and first flowed at high speed through the opening into the pool before running through a channel – in the first phase located lower and with a smaller cross-section, in the later phase positioned higher and with a larger cross-section.

After detailed examination of the layer of lime on the masonry and in the opening, it appeared that a rectangular 30- to 45-centimetre opening was originally constructed in the masonry and later took on a triangular shape due to lime accumulation. The ease with which these dimensions can be converted into one or one and a half Roman feet indicates that this is not one of the notorious cases of water theft by tapping the lines – of which the Roman technical author Frontinus (ca. AD 30 to 100) complained many times. Rather it is a planned diversion, for which it was apparently attempted to



achieve pressure by artificial means in the interior of the Aqua Marcia. According to a first estimate, up to about a hundred litres of water per second could have been tapped off and discharged here.

Is this diversion the Villa Adriana branch we are seeking? Is the tank

the forebay of a pressure line starting from this point, which brings the water through one or more lead pipes to the slope of the residence located opposite it? Would this amount of water suffice to supply the many hydraulic engineering installations?

We are unable to answer any of these questions based on our present knowledge. The one thing that appears certain is that there was a planned, well-executed diversion from the Aqua Marcia here. But these diverting channels themselves complicate the situation: There must have been a rather small channel in the first phase, which was directed somewhat farther to the south-west than the later channel (second phase) sitting atop it, which ran more towards the west. If the second-phase channel emptied into the tank, then this tank was also part of the second phase. Its different type of use after the modifications were made



would then have to be viewed as a third phase. But then no more water could have been taken from the Aqua Marcia. Contradicting this is the fact that the outlet opening is closed not with brickwork but with lime deposits from the water.

But if the tank is to be viewed as a completely new construction, which intersected and destroyed the two earlier diversion channels (third phase), then there must have been a third stage of development moving the water from the pool mentioned above at the Aqua Marcia to the new forebay of the pressure line, of which, however, no trace can be found. The conversion of the tank would then have to be defined as the start of a fourth phase. Whether the visible phases of the structures at the water removal point can be reconciled logically with the structural development of the hydraulic installations of the Villa Adriana is still open to question.

The question of whether the amount of water to be removed here can have met the needs of the Villa Adriana is also unanswerable at present. The estimated flow through the villa is about four times the amount of water which the 10,000 inhabitants of Pompeii received through their long-distance aqueduct in imperial times. Furthermore, according to the contemporary author Frontinus, the water of the Aqua Marcia was of the highest quality. What is more, there is probably no consumer in the immediate vicinity whom the emperor would have granted such a great quantity of it. On the other hand, it is not at all clear how much water was used in the Villa Adriana, whether there was sufficient storage capacity in reservoirs or whether the water in the installation on the slope of the Villa Adriana could be stored temporarily and so reused. With the number and size of hydraulic engineering facilities, the amount of water from this branch may well seem low, but perhaps it would be sufficient with the water that was possibly brought in from other aqueducts.

In summary: The work here is yielding extraordinarily interesting and promising results, but raising a new set of questions at the same time.

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When Gods Become Visible

The Jenu Kurumba are hunters and gatherers. Their tribal rituals reveal surprising aspects of the social system of this Indian community

The Jenu Kurumba, a tribe inhabiting the northern edge of the Nilgiri Plateau in southern India, are a community of hunters and gatherers with their own, unwritten, language and their own social system. In their rituals the Jenu Kurumba convey “visual knowledge”, a matter of fundamental significance for their cultural self-perception. Especially in the rituals for the Dead, the actors perform meaningful figures incorporating fundamental statements regarding their own community. Knowledge is publicised in cultural performances, visible to all and, moreover, presented in an expressly theatrical manner.

At the centre of the Jenu Kurumba’s ritual performances lies the visualisation of two key metaphors conveying the ideal of a moral community. One key metaphor defines the good community as a household in which the generations cooperate with each other just as people do who are related by marriage or descent. A further metaphor presents the concept of a comprehensive community which embraces its deities and its Dead, too. The first image of community as a family household is especially highly developed in rituals of the Dead. Here a series of symbolic image sequences depicts the moral community as a place of lively, practical fellowship. In the opening scene, leafy green saplings cut from a special tree are borne with theatrical ceremonial in a sort of procession to the site where the ritual is to be enacted. After this, everyone brings water from a river, and fetching

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wood for the fire, as well as bringing food, are enacted. The performance eventually reaches its climax with the construction of a small bower to house the gods and the Dead during the course of the ritual. With the water pitchers, food, firewood and the burning fire, the formerly empty and deserted site is transformed into an inhabited camp site. The construction of the bower is followed by the social animation of the ritual site. Relatives of the one or more deceased prepare food for all the participants, and sacrifices (such as food and incense sticks) are made to the gods and the souls of the Dead. The final act takes place in the evening, when the good community is presented to the gods and the souls of the Dead in the form of a communal feast accompanied by music, singing and dancing. In this manner, as the ritual progresses a representation of the community takes form which everyone can both see and experience.

The Jenu Kurumba visualise further important elements of their social concept with a second image of a community shared with the gods, and thus all-embracing. This representation is also mainly to be found in the ritual for the Dead. The Jenu Kurumba believe the gods and the souls of the Dead incorporate themselves in the shamans of the tribe and speak with the Living. Thus embodied, they demonstrate their affinity with the Living and their membership of the moral community. They distribute the green saplings used for the bower, they fetch the water from the river, they hand round the filled water pitchers to the waiting women, and they





promise the Living their support in times of crisis. On the other hand, for their part they demand solidarity and support. Thus, the gods make gestures to demand a beaker of drinking water, or even a cigarette. The shamans embody the Dead, so they are able to show their suffering and need for help. They run crouched, and hold their sides in pain, they lean on their relatives or on a stick, lament, weep or embrace the Living. In this manner, the Jenu Kurumba believe the Dead can also play an active role in the staging of the communal concept.

The deities and/or the Dead also underscore their visible presence in a series of characteristic ways. The act of embodiment alone often takes the form of a dramatic display in which the shaman quakes wildly, stumbles around, throws his arms about, and is quite often on the verge of falling to the ground. Their characteristic motions also make the shamans the centre of attraction. They stride rapidly up and down,

An ancestral deity of the Jenu Kurumba. Like all deities, it displays itself to its living relatives in the form of a mask. It is honoured by rituals involving gifts and incense sticks. In the presence of the deity, the members of the tribe also relate their problems and desires.



they are also, however, restless when they pause, and their speech is clipped and breathless. In contrast to this, the Living remain more or less tied to one spot, their places having been allocated to them by the gods. Sometimes the gods carry staves which, like their gestures and mimicry, emphasise their authority. Thus they raise their hand or their forefinger in warning or, whilst turning in a circle, they point to the four cardinal points of the compass. At other moments they point alternatively to the ground and the sky, thus emphasising their responsibility for all aspects of the community, the underworld and the upper world of human beings. In other scenes, the gods are represented as guardians of the moral code. For this purpose the shaman fetches the Living from the periphery of the ritual site to its centre and lines them up in a row in front of him. In a sort of court hearing the embodied deities, (or the Dead,) call the Living to account over their failings. They remind their relatives of their obligations, and recall to mind the moral values of the community. They frequently dramatise their anger over moral shortcomings by stamping their feet, breaking their staves, raising their voices, or by use their staves to describe a circle round



Death ritual of the Jenu Kurumba – a dead person, enacted by a shaman (naked from the waist up) is led to the ritual site. The saplings will be used to construct a bower for the deceased (below right). Below left: Rice is presented as a symbol of solicitude; enforcing reconciliation between the Living and the Dead, the shaman embraces the bereaved. In this manner the ideal of an all-embracing moral community is visualised.

particular people in order to denounce them as being particularly imperfect. Nevertheless, the Living are not entirely powerless against the gods: they defend themselves, contradict and remind the deities of their obligations, too. As a rule, these conflicts end in mutual reconciliation and acknowledgement of the moral community, which all the





participants witness through clearly visible symbolical gestures.

By visualising such debates in a public place and enacting them as rituals, the participants present the moral community to all the onlookers and to themselves as an all-embracing community for argumentation and debate. This picture makes it clear that the moral community not only demands cooperation and solidarity, but also needs its deities, its Dead and continuous debate over what is "good" and

what is "bad", as the Jenu Kurumba say. In both these pictures of communal life, the Jenu Kurumba convey the visible knowledge of central elements of their social order. In many cultures, political and religious power lies solely in the hands of the menfolk. Participation in rituals is strictly limited to men, to the exclusion of all women and girls. With the Jenu Kurumba it is different, and in essence every member of the tribe can, and should, participate – either actively or as a spectator. Moreover, both the key

**In tribal rituals
the Jenu Kurumba
convey visible knowledge
of central elements of
their culture**

metaphors have their origin in the egalitarian social order of this hunter-and-gatherer culture. The image of the household signifies that the community can only thrive through the cooperation and involvement of all its members. This picture of the community, which also embraces its deities and

Dead, makes it clear that in this egalitarian community nobody, in the end, holds the power to subjugate any other members of the tribe. Instead of this, the moral values of the

community are negotiated in its rituals. Back at the beginning of the last century, Bronislaw Malinowski, one of the founding fathers of modern anthropology, demanded that research into an alien culture should be conducted from the "natives' point of view". Investigation of visual culture presents a new approach. The "visible knowledge" in rituals is performed as a series of poetic images, thus enabling the social and cultural concepts of the community to be visualised, too. At the same time, this knowledge stands in di-

rect relation to the relevant social structures. Finally, it comes into its own in times of crisis when the binding power exercised by the codes of values and the systems of orientation are under threat. Rituals are dependent upon active participation and can only be passed on and preserved through participation. The actors are aware of the role of visual knowledge, and ascribe great importance to their own performances. Absence of ritual not only undermines the moral code and the social relationships, but at the same time signifies the loss of the deities. When Malinowski spoke of the natives' point of view he meant more their concepts rather than their visual culture. Two generations later, Margaret Mead was to lament the neglect of the Visual in ethnology, and demanded its documentation. This change in emphasis entailed a major challenge to modern visual anthropologists: the interpretation of the Visible in an alien culture. When meanings are also to be conveyed via images, language analysis alone is not enough. To this must be added investigation of the Visual.

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The Revival of a Great German Library

Detailed detective work reconstructs the book and manuscript collection of town clerk Konrad Peutinger from Augsburg. A contemporary of Luther, he set up one of the most important humanist libraries of his time

He was the creator of one of the most important scholarly libraries of his time in the German-speaking lands – the humanist Konrad Peutinger from Augsburg. The lawyer and politician was thus one of a small elite of highly qualified experts who significantly contributed to shaping political and cultural life in the free imperial towns of southern Germany around 1500 and during the first decades of the 16th century. Due to his close relationship with Emperor Maximilian I he also played an important role in the German Empire.

Konrad Peutinger (1465 to 1547), born in Augsburg as the son of a prosperous businessman, laid the foundations of his successful career by studying in Italy from 1482 to 1488. In Padua and in Bologna, in Florence and in Rome, he not only acquired outstanding legal expertise, he also familiarised himself with the entire educational canon of the time. In 1490, after returning to his native city of Augsburg, he found employment in the municipal administration. His permanent appointment as town clerk in 1497 then put him in charge. In this capacity, he had great influence on the politics of the city which, with its leading banking and business houses, was at that time the most important economic center in the Empire. As town clerk he represented the city in the Swabian League, at Imperial Diets and with the Emperor. In the city itself, Peutinger reformed the administration, the town court and the welfare system, among other things. He was also a sought-



In a scholarly library, Konrad Peutinger, 1465 to 1547, collected the entire body of knowledge of his time. He adorned particularly valuable books with his ex-libris (above). The portrait of the humanist is by Christoph Amberger.

after and well-paid legal expert for other free imperial towns, as well as for private individuals and commercial firms. In 1498, he married Margarete Welser (1481 to 1552), whose father was the head of the second most successful business in Augsburg (after the House of Fugger). Thus he finally became established as part of the town's upper class.

As early as 1491, Peutinger was part of an inner circle of advisers to Emperor Maximilian who entrusted him with numerous political and diplomatic matters until the end of his reign in 1519. The Emperor also

assigned him important tasks in the realisation of his artistic-literary projects. Although his relationship with Maximilian's successor Charles V was not as close, Peutinger managed to maintain his position in Augsburg as well as in the Empire for some time. Only in 1534, after his efforts to reconcile the quarrelling religious parties had failed and the reformation had started in Augsburg, did he resign from his post as town clerk. Peutinger's scholarly work consisted primarily of publishing historical works. He also initiated or promoted many editions by lending out manuscripts. His collection of Roman inscriptions from Augsburg and the surrounding area, published in 1505, was a pioneering achievement. Peutinger's own literary work was not as significant. His main work, a methodologically advanced history of the emperors from Roman times to Maximilian I on which he spent around two decades, remained incomplete. It exists today only as a collection of manuscripts.

The most indispensable tool for all of his many activities was his library, which he continually expanded over the course of over 60 years. With more than 6,000 titles in approximately 2,200 volumes, it spanned the entire first century of printing, from Gutenberg's "Turkish Calendar" (1454) to John Calvin's "Catechism" (1547). There is nothing else of its kind in Germany, or perhaps even north of the Alps.

In the middle of the 16th century, there existed a number of collec- 17

tions owned by bibliophile princes and rich businessmen, such as the Fuggers, which mainly served as prestige objects rather than as reading material. Peutingering's library, however, was predominantly a working library. Its diverse range of subject areas corresponded to Peutingering's universal interests. The library's strongest areas were in grammar, poetry, geography, philosophy and theology and particularly history, rhetoric and medicine. Ancient and medieval literature was represented as strongly as the works of contemporary authors. Peutingering especially valued the Roman writers Cicero, Plinius the Elder and Plinius the Younger, Church Father Hieronymus and the humanist Desiderius Erasmus. A separate room was devoted to his equally well-stocked legal library.

After Peutingering's death, the library, as decreed in his will, remained with the family for more than one and a half centuries. During the lifetime of his last male descendant, the library began to be fragmented, starting with the sale of its most famous work, the "Tabula Peutingeriana", a medieval copy of a map of the world from Late Antiquity which is now in the Austrian National Library in Vienna. When in 1718 the last Peutingering died and bequeathed his famous ancestor's library to the Augsburg Jesuits, the collection suffered further losses. Immediately after the collection had changed hands, several volumes, including a number of treasures, ended up in the English antiquarian book trade. In the subsequent years, many more books were sold. Later, the Jesuits arranged the remaining volumes among their own books, so that the former Peutingering library no longer existed as a unit.

More substantial losses were incurred as a result of the abolition of

the Order of the Jesuits in 1773. When Augsburg fell to Bavaria in 1806 the most precious volumes went to the Munich Court library. Amongst them was the "Turkish Calendar" mentioned above, the only existing copy. The remaining books of the former Jesuit library, which still contained at least half of the original Peutingering collection, were then handed over to the predecessor of today's Augsburg State and City Library.

The fragmentation of Peutingering's library continued despite the academic interest in Peutingering's life and work, which began in the 18th century. Unapprised librarians in the 19th and even the 20th century often removed the prints that had been bound together from their original bindings in order to be able to put them in alphabetical order. Thus, what was probably the most comprehensive scholarly library of the

existing old catalogues form the basis of this enterprise. The first two were Peutingering's own, which however only include about half of the volumes. Additionally, there is a complete inventory of the library and of the rest of the estate that was compiled 50 years after his death. Finally, comprehensive source material exists from the middle of the 18th century when the books were already in the possession of the Augsburg Jesuits.

Gradually, the number of books originating from the Peutingering library has increased to around 40 percent of the original total, about three quarters of which are now in the Augsburg State and City Library. In addition, a considerable number are owned by the Bavarian State Library in Munich, the Academic Library in Dillingen and the British Library in London. Other volumes are scattered

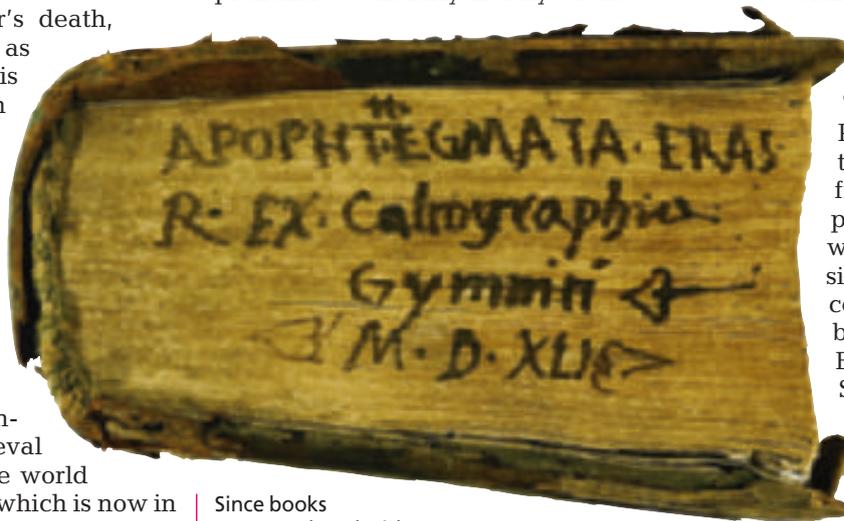
across the world from New York to St. Petersburg.

The sheer size of Peutingering's collection can be surmised from the remaining parts in Augsburg, which are equal in size to that of other complete humanist libraries such as that of Beatus Rhenanus in Schlettstadt.

The project members are breaking new ground by attempting to determine as closely as

possible even titles that no longer exist in the original. They are basing their investigations on relatively precise information in Peutingering's historical catalogues, as well as on the electronic cataloguing of old stock and the increasing accessibility of 15th and 16th century prints (projects specifically funded by the DFG). As a result, we have relatively reliable data on about a further 40 percent of the original collection, leaving only 20 percent about which we have no or only very vague information.

In addition to the search for titles and the description of the existing volumes, historical catalogues will

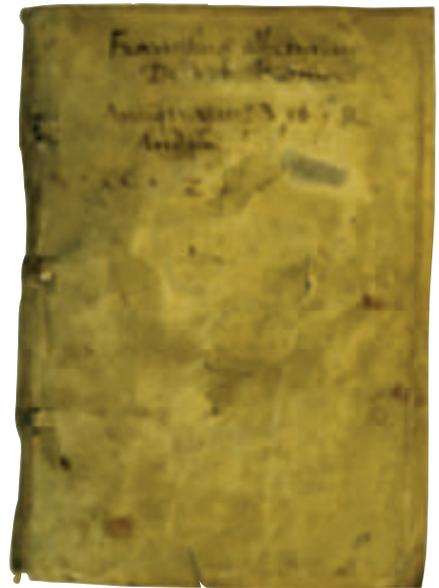


Since books were produced without either a publisher's cover or a spine label, important information was written on the fore or tail edge of the book: label by Peutingering on a work by Desiderius Erasmus, printed in 1541.

German-speaking world fell into oblivion. Despite these rather unfavourable conditions, an interdisciplinary research group has decided to study this unique collection. It is their aim to investigate and describe the verifiable manuscripts and prints, to reconstruct the missing volumes and to make the contents of the manuscripts accessible. The



The Triumph of Death: colour illustration from Konrad Peutinger's prayer book and book of hours. Miniature on parchment, around 1500. Top right: a page inscribed by Peutinger, underneath a pen and ink drawing of a cornflower with a banderole.



be published in order to allow verification of the information. Furthermore, the two Peutinger catalogues have a value in their own right as historical library documents. Peutinger's cataloguing is an almost perfect example of an attempt to order and make easily accessible the explosion of information that followed the invention of the printing press. Through a combination of various, relatively modern methods of cataloguing (such as subject-, keyword-, location-, and alphabetical catalogues), Peutinger achieved a standard that only much later came into general use.

One of the most significant results is the re-evaluation of Peutinger's manuscript collection, which had previously been entirely underrated. The approximately 200 volumes of his collection consisted mainly of medieval codices, copies of such codices, and a set of reference texts from legal practice. The fact that

many of those manuscripts originated from the Peutinger library was previously unknown.

With this reconstruction, which will consist of three text volumes and one index volume, Peutinger's vanished library will re-emerge. Academics from many fields will thus gain access to rewarding material for follow-up research, particularly since an evaluation of the library within the context of the current project must remain limited.

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This has surely happened to you: you park your car under a lime tree in the middle of summer and after a short time the roof and doors are sticky, as though sugar water had been poured over them. The culprits can be found in the tree right above the parked vehicle: aphids commonly sucking on the liquid in the sieve tubes (phloem) of plants and releasing a sugar-rich substance that settles like dew. This has given the phenomenon its name: honeydew. In Biblical times, it was probably the sugary excretion product of a scale bug that was the manna which saved the Israelites from starvation while crossing the Sinai desert.

From a chemical perspective, honeydew is a mixture of various carbohydrates, amino acids and other plant substances. Sugar usually constitutes about 98 percent of its dry weight. While plant ingredients and amino acids all come from the phloem sap, the carbohydrate composition of honeydew clearly differs from that found in the liquid in the sieve tubes of the colonised plants. The phloem sap of the plants almost exclusively contains the disaccharide sucrose, whereas aphids are able to produce a number of carbohydrates not found in the phloem sap—for example, the trisaccharide melezitose.

Honeydew is important in particular for ants. Many species satisfy the carbohydrate needs of their entire colony from this secretion alone, which they usually take straight from the feeding aphid. Finding highly productive sources of honeydew and defending them against competitors is therefore important to these species. As a result, those aphid species that produce particularly large quantities or a high quality of honeydew should be preferred. The aphids also benefit from this co-existence. The ant-attendance prevents their pollution by the honeydew and protects the aphids from predators and parasites.

A suitable plant for studying the complex set of relationships between aphids and ants is the common tansy, a perennial herb of the daisy family, which is often encountered on roadsides, rubbish dumps

Of Aphids



and Ants

Aphids produce honeydew from the liquids of their host plant. Ants love this sugary substance

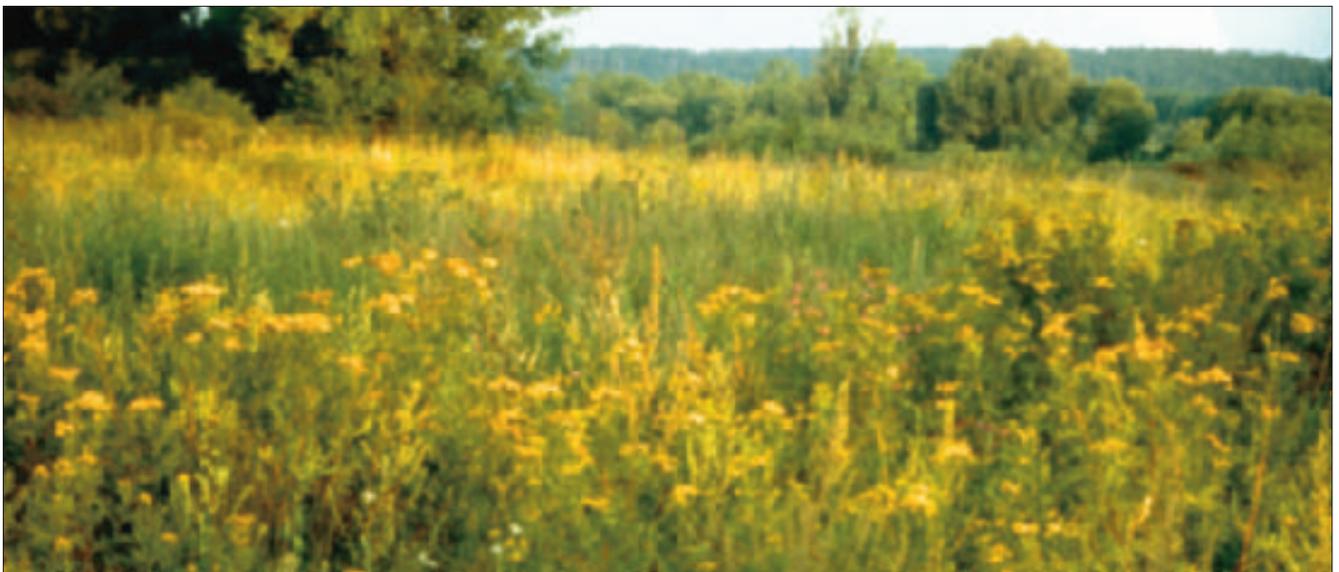


and riverbanks. Eight species of aphids live on different parts of this plant. *Metopeurum fuscoviride*, *Macrosiphoniella tanacetaria*, *Aphis fabae* (the black bean aphid) and *Brachycaudus cardui* (the thistle aphid) all feed on the stem while forming large, dense colonies there. *Coloradoa tanacetina* and *Uroleucon tanaceti* live in small, loose colonies on leaves. *Aphis vander-gooti* and *Trama troglodytes* exclusively feed – largely hidden from the human eye – in dense colonies at the neck of the roots and on the roots themselves. Four of these species are exclusive to tansies, while the others can also live on other plants. In the context of a project at the University of Bayreuth, the composition of honeydew produced by tansy aphids has been analysed in recent years, their honeydew production measured and their relationship with the black or garden ant, *Lasius niger*, the most common ant species in Central Europe, studied.

The first astonishing result was that even though they feed on the same plant, the honeydew sugar composition of different aphid species clearly differs. In five species the trisaccharide melezitose formed by the aphids was the dominant sugar ranging from 45 to 70 percent, but it made up only a small portion (less than 10 percent) for the three other species, *Macrosiphoniella tanacetaria*, *Coloradoa tanacetina*, and *Uroleucon tanaceti*. Instead, these species produced a larger portion of erlose, another trisaccharide, with an average of 10 to 20 percent. In all species, the



The black ant, *Lasius niger* (large picture) is attracted by the particularly high-quality honeydew of *Metopeurum fuscoviride*. Many ants cover the carbohydrate needs of their entire colony with this secretion. The aphids also benefit from this coexistence. From left to right: *Macrosiphoniella tanacetaria*, *Metopeurum fuscoviride*, *Aphis fabae* and *Coloradoa tanacetina*.



Ants only visit *Aphis fabae* when no better alternative is available. Tansy blooms bright yellow from June to September, usually on roadsides and riverbanks. It is an attractive source of nutrients for many blossom visitors. As many as eight aphid species feed on its leaves, stems and roots.

monosaccharides glucose and fructose, the disaccharides sucrose, maltose and turanose, and the trisaccharide raffinose were routinely found. Although the relative proportions also differ between species, no clear pattern comparable to melezitose and erlose was

found. Trehalose, the blood sugar of insects, was also found in the honeydew of all species and constituted from 5 to 30 percent. Surprisingly, xylose, a phloem sap sugar with five carbon atoms that is difficult to metabolise by insects, also occurred.

The average sugar concentrations in honeydew also differ between aphid species. The total sugar content for the *Aphis fabae* and the *Brachycaudus cardui* is between 40 and 60 milligrammes per millilitre of honeydew, and the highest values are found with *Metopeurum fuscoviride*, *Aphis vanderghooti* and *Trama troglodytes* with 80 to 100 milligrammes per

millilitre. In the other three species the total sugar concentration was below 30 milligrammes per millilitre. A high total sugar content was also always associated with a high melezitose portion.

Surprisingly, a link between the age of the animals, nutrient availability to the host plant and sugar composition or sugar concentration in the honeydew could not be found for any of the aphid species studied. This is all the more astonishing because the development and reproduction of aphids strongly depends on these factors. Possibly, the carbohydrates, which are abundantly available in their food, have no effect on the development and repro-



A special life support: Without the support of ants, *Macrosiphoniella tanacetaria* cannot rid itself of its excess honeydew. The large honeydew drops gather at the aphid's anus causing a life-threatening pollution.

duction of aphids, but changes in the availability of amino acids do. This is indicated by the age dependency of the amino acid concentration in the honeydew of *Metopeurum fuscoviride*.

A link between melezitose content and total sugar concentration is also suggested for honeydew production. The higher the values, the more honeydew was secreted by the aphids. The absolute leader is *Metopeurum fuscoviride*, with a single aphid secreting up to an average of 1,000 microgrammes of honeydew per hour. *Aphis vandergooti* also secreted a respectable amount of honeydew with 500 microgrammes per hour. By contrast, the production of *Aphis fabae* and *Brachycaudus cardui* (between 150 and 200 microgrammes per hour) and especially of *Macrosiphoniella tanacetaria*, *Coloradoa tanacetina* and *Uroleucon tanacetii* (each below 50 microgrammes per hour) was strongly reduced.

The differences in honeydew quality and quantity have a marked effect on the mutual dependence of aphids and ants. As could be demonstrated, black ant prefers honeydew sources with a high melezitose concentration. However, this alone does not make a particular aphid species attractive. A sufficient amount of honeydew must be produced to make the ants' effort to collect it worthwhile. Therefore, the black ant does not visit the three aphid species with the lowest honeydew production and at the same time a low melezitose concentration. There is a decided hierarchy among the other species as well: the ant exhibits a definite preference for *Metopeurum fuscoviride*, from which it collects most intensively, while at the other end of the scale *Aphis fabae* is only visited when there are no alternatives.

The ants maintained this pattern in so-called choice trials: colonies of a less preferred aphid species were simply abandoned when a more attractive species was offered. There is, therefore, genuine competition among aphid species. If the ants give up a colony of a less preferred species when a more "appetising" species has established itself nearby, dramatic repercussions soon result. The absence of the ants allows predators to successfully feed in the "defeated" colonies, and the survival rate declines.

Do some aphids produce a melezitose-rich honeydew to attract ants and to use the associated advantages? After all, the production of melezitose and the related association with ants offers many benefits. Nevertheless, it appears more probable that physiological reasons are the determining factor. Earlier research assumed that melezitose plays an important role in the regulation of the water balance in the aphid's intestine. The results of the Bayreuth study, which show a clear correlation between total sugar concentration and the melezitose portion, also support this hypothesis. The advantage for the aphid would then result from physiological necessity.

Why does the black ant prefer melezitose? Studies in Denmark have shown that the nutritional value of melezitose is far lower for the ant brood than that of "ordinary" sucrose, so we can rule out a preference for a high-quality diet. Alternatively, melezitose may have a signal function since a high melezitose content in the honeydew is associated with both high sugar concentration and strong honeydew production. In that case, the preference for melezitose is not a preference for this particular sugar but a reaction to an important indicator agent. Is melezitose perhaps of no biological value to the ant? Is it only a drug for ants?

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 Dr. Melanie Fischer
 PD Dr. Wolfgang Völkl
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 Universität Bayreuth

Since man began farming, the formerly uninterrupted woodlands of Central Europe have become arable farmland, pastures and settlements. In Germany only a third of the country is still covered by woods, now dispersed in numerous smaller and a few larger fragments. This benefits some animal species. But exclusive forest animals have a problem: suitable habitat no longer exists in continuous areas but merely as "islands" surrounded by a "sea" of open land. This situation is found in many parts of the world.

The reduction of species-specific habitat to islands is one of the most important causes of the decline and extinction of populations and species of larger vertebrates globally. To be able to survive in the long run in fragmented habitat, there are two options: either the species retreats into the few areas which are large enough, or it migrates between the various fragments. Conservation biologists need to assess under which conditions which of the options appears viable.

The capercaillie is a good example. As a typical Taiga dweller it de-



Life Sciences

The Capercaillie and the Quest

Where once continuous woodlands existed, only "islands" now remain in a "sea" of open countryside. What impact does this have on species such as the capercaillie?

depends on open, coniferous forests. In Scandinavia and Siberia the capercaillie lives in extensive wooded areas. However, in Central Europe its distribution is restricted to the Alps and the lower mountain ranges: Only here are forests similar to the Taiga to be found. Studies in

ie ion of Survival



Norway and Germany in the 1980s and 1990s on birds fitted with small transmitters demonstrated a use of much larger areas than formerly assumed. Both the cock and the hen used several hundred hectares of forest in the course of the year and their traditional mating grounds attract birds from distances of several kilometres. Since then there has been speculation that it is not only



The capercaillie is the symbol of a healthy mountain environment. In Central Europe it only occurs in the Alps and a few lower mountain ranges. This threatened species demonstrates in an exemplary manner, how important regional approaches are in conservation. A genetic fingerprint can be obtained from dead material such as moult feathers – a new method for performing research on threatened species.

the quality, but also the area of a habitat, which is significant for the survival of capercaillie populations.

Central European capercaillie habitats are fragmented on two levels. The larger areas of forest in which they occur – such as the Vosges, the Black Forest and the Alps – are fifty to a hundred kilometres apart from each other. However, the forest is also broken up internally and permeated by farmland, settlements and roads in these regions. For example, in the Bavarian Alps the capercaillie inhabits the higher reaches of forested mountains.



Despite a large proportion of forested land, as in southern Bavaria, larger forest-dwelling species are absent from agricultural landscapes. There is not enough space in small forest fragments. Destruction of habitat, as in clear-cutting in the virgin forests of the Urals (right), not only means loss, but also fragmentation of the remaining patches.



A pattern of separate, more-or-less isolated habitat islands results because of the open valleys in between them. Most islands are between ten and a hundred square kilometres in size and form a habitat for ten to at most a hundred capercaillies. Can this type of localised population survive even if it is isolated from its neighbours?

There are demographic and genetic approaches for assessing the chances of a population surviving. The former focus on random fluctuations in population and the environment, the latter on the maintenance of genetic diversity. Using model calculations based on demographic variables from the Bavarian Alps, a population size of 500 individuals is suggested to ensure the

survival of a population with 95 % certainty for the next hundred years – providing the habitat does not change. Furthermore, a population of this size is not genetically limited in its ability to survive over the medium term. Nevertheless, it is obvious that it cannot fully represent the diversity formerly found in Central Europe. In the long run, it may therefore lack the adaptability to cope with future environmental changes.

Model calculations of the minimum size of a population capable of survival must not be overinterpreted. The relationships of population dynamics are far too complex to provide precise predictions of the duration of survival. Normally, it is sufficient to compare orders of magnitude. If long-term survival seems to require several hundred capercaillies, but a habitat island only has room for a population of fifty birds, there is no doubt that its chances of

survival must be considered low. The chances increase sharply, however, if several of these islands are interlinked. This finding suggests that capercaillie populations in the Alps and similarly fragmented areas will only survive in the long term if they have contact with their neighbours – that is if they live within the association of a metapopulation.

A metapopulation is characterised by a spatially dispersed distribution, local populations with a largely independent dynamic, the exchange of migrating individuals and a not insignificant risk of extinction for at least some local populations. The chances of a metapopulation's survival rise with the number of interconnected subpopulations, their sizes and the frequency of individuals migrating between them. Migrants can balance out local fluctuations in population size, recolonise abandoned areas and maintain high genetic diversity. Among vertebrates, juveniles settle elsewhere after becoming independent. The extent to which juveniles tend to migrate depends on the species as well as on the benefits and risks of migration. In habitats that continuously change naturally, species often exhibit a very pronounced ability to migrate, while this behaviour is less developed in species in a more constant environment – such as the capercaillie. Migration distances also vary within a population: short distances are common, but long distances are scarce.

In contrast to the closely related black grouse, the capercaillie is not very likely to migrate. Only a few juveniles – usually the females are more mobile – migrate into neighbouring habitat islands, while most remain where they were raised. Until recently, only a qualitative assessment of the extent to which capercaillie and black grouse populations exchanged individuals was possible by observation of migrating individuals. Even a decade ago, genetic analysis was only possible with fresh blood or tissue, and was therefore not justifiable for threatened species. Since then, conservation biology has begun to use methods familiar in criminology. Minute amounts of DNA obtained from

dead material such as hair, faeces or feathers suffice for a genetic fingerprint. The samples needed by this sophisticated laboratory technique are supplied by time-consuming collection in the field. Thousands of moult feathers were collected for the work on capercaillies and black grouse. In the laboratory, species-specific microsatellites were multiplied and analysed from the nuclei of cells attached to the feather's pin. Microsatellites are markers suitable for identifying individuals, determining kin relationships, quantifying genetic differences and recognising population collapses. The great variability of microsatellites makes it possible to assign individuals to their populations of origin



At two to two-and-a-half kilograms the capercaillie hen weighs half as much as the cock. Both cock and hen roam over several hundred hectares of forest in the course of the year. Only a few juveniles migrate into neighbouring populations.

with a high probability. It is now clear from the analysis of microsatellites from feathers that the Central European populations of the capercaillie are isolated. Capercaillies no longer migrate even between the Black Forest and the Vosges, which are only 50 km apart as the crow flies. The contact probably broke down a few decades ago when populations declined and fewer chicks were raised – too few

to produce a sufficient number of long-distance migrants. The causes lie with habitat deterioration on a large scale as a result of changing land use by humans. In the Alps regular migrations from one mountain to another can still be demonstrated. Nevertheless, capercaillie populations on neighbouring mountains are clearly genetically differentiated even if they are only five to ten kilometres apart. This confirms that only few juveniles emigrate. Since most migrants fly no further than the neighbouring mountain, their genes only have a chance of reaching the next population in the following generation. Therefore, there is a close relationship between geographic and genetic distance.

Where barriers such as the high mountain ranges of the Central Alps restrict migration routes, on the other hand, even an exchange over short distances may be next to non-existent.

For conservation efforts, which have a traditionally local outlook, perhaps the most important lesson to be learnt from research on metapopulations may be that the observed localised population dynamics may have regional causes. A population may appear stable because of similar annual counts – but it may in fact solely survive because of immigration from neighbouring areas. The population's extinction may not be caused by a decline of the local habitat but a failure of immigration.

In the Alps, the capercaillie inhabits mountain forests separated by open countryside in the valleys. Each mountain constitutes a habitat island with a local population. Without contact with each other through migrating individuals, they would barely survive. Juvenile migration is critical for the dynamics of overall populations. The more juveniles that mature, the more migrants can be anticipated.

This situation is evident on the northern margin of the Alps. The foothills – the northernmost edge of capercaillie distribution in the Alps – are often not good capercaillie habitats because of intensive forestry and high precipitation. However, they are still inhabited by capercaillies. The various users of this habitat, above all forestry, take this as proof of their capercaillie-compatible forest management, but genetic data reveals a different picture: many capercaillie stocks in the marginal areas are solely kept alive by immigrants from more productive parts of the metapopulation. If immigration stops because source populations decline, extinction is just a matter of time.

As long as the regional relationships are neglected, conservation of the capercaillie and other threat-



ened species misses the target. To preserve metapopulations, exchange must be ensured. For some species it may be helpful to preserve migration corridors or to create stepping stone areas, but for Central Europe's capercaillies the problem is less in reaching neighbouring areas than the decline in the number of young birds and potential migrants. An active exchange is best ensured with large populations and good chick-raising conditions in as many

subpopulations of a metapopulation as possible. This cannot be achieved by scattered local efforts. In conservation biology the metapopulation concept and its application to species in fragmented habitats has initiated a rethink: perspectives are shifting away from the local level towards regional and interregional perspectives. The metapopulation concept has not only become an important explanatory framework in research, but it also successfully demonstrates the necessity of interlinking on a wider scale as a prerequisite for species protection in ecosystems with a strong human influence. An obstacle to the concepts' acceptance in practical conservation is that to date many theoretical, but few empirical studies are available. They are often methodically difficult, especially with large animals, suffer from small sample sizes and are considered scientifically unproductive. To convince practitioners of the importance of regional approaches, case studies such as those on the capercaillie and black grouse are important learning exercises. They demonstrate the metapopulation character of a population system and consequences for its dynamic and conservation.

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The Deutsche Forschungsgemeinschaft

The Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) is the central self-governing organisation responsible for promoting research in Germany. According to its statutes, the DFG serves all branches of science and the humanities. The DFG supports and coordinates research projects in all scientific disciplines, in particular in the area of basic research through to applied research. Particular attention is paid to promoting young researchers. Every German scientist and academic is eligible to apply for DFG funding. Proposals are submitted to peer reviewers, who are elected by researchers in Germany in their individual subject areas every four years.

The DFG distinguishes between the following programmes for research funding: In the *Individual Grants Programme*, any researcher can apply for financial assistance for an individual research project. *Priority Programmes* allow researchers from various research institutions and laboratories to cooperate within the framework of a set topic or project for a defined period of time, each working at his/her respective research institution. A *Research Unit* is a longer-term collaboration between several researchers who generally work together on a research topic at a single location. In *Central Research Facilities* there is a particular concentration of personnel and equipment that is required to provide scientific and technical services.

Collaborative Research Centres are long-term university research centres in which scientists and academics pursue ambitious joint interdisciplinary research undertakings. They are generally established for a period of 12 years. In addition to the classic Collaborative Research Centres, which are concentrated at one location and open to all subject areas, the DFG also offers several programme variations. Transregional Collaborative Research Centres allow various locations to cooperate on one topical focus. Cultural Studies Research Centres are designed to support the transition in the humanities to an integrated cultural studies paradigm. Transfer Units serve to transfer the findings of basic research produced by Collaborative Research Centres into the realm of practical application by promoting cooperation between research institutes and users.

DFG Research Centres are an important strategic funding instrument. They concentrate scientific research competence in particularly innovative fields and create temporary, internationally visible research priorities at research universities.

Research Training Groups are university training programmes established for a specific time period to support young researchers by actively involving them in research work. This focuses on a coherent, typically defined, research and study programme. Research Training Groups are designed to promote the early independence of doctoral students and intensify international exchange. They are open to international participants. In International Research Training Groups, a jointly structured doctoral programme is offered by German and foreign universities.

Other funding opportunities for qualified young researchers are offered by the *Heisenberg Programme* and the *Emmy Noether Programme*.

Humanities Research Centres were created in the new federal states to improve the existing research infrastructure. These centres have been established for a specific time period and serve to promote interdisciplinary research.

The DFG also funds and initiates measures to promote scientific libraries, equips computer centres with computing hardware, provides instrumentation for research purposes and conducts peer reviews on proposals submitted within the framework of the *Hochschulbauförderungsgesetz*, a legal act which provides for major equipment and the construction of institutions of higher education in Germany. On an international level, the DFG has assumed the role of Scientific Representative to international organisations, coordinates and funds the German contribution towards large-scale international research programmes, and supports international scientific relations.

Another important role of the DFG is to provide policy advice to parliaments and public authorities on scientific issues. A large number of expert commissions and committees provide the scientific background for the passing of new legislation, primarily in the areas of environmental protection and health care.

The legal status of the DFG is that of a private association. Its member organisations include research universities, the Academies of Sciences and Humanities, the Max Planck Society, the Fraunhofer Society, the Leibniz Association, the Helmholtz Association of National Research Centres, research organisations of general importance, and a number of scientific associations. In order to meet its responsibilities, the DFG receives funding from the German federal government and the federal states, as well as an annual contribution from the Donors' Association for the Promotion of Sciences and Humanities in Germany.

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Illustrations

Hoffmann (cover, pp. 20, 21, 22, 23),
Querbach (p. 2, back), Depenthal (pp.
4/5, 5 a., 6, 7), Steinmetz (p. 5 b., 7),
Ohlig (pp. 8/9, 9, 10, 11), Demmer
(pp. 12/13, 14, 14/15), Stadt Augsburg
(pp. 16, 17, 19 l.), Künast (pp. 18, 19),
Storch (pp. 24, 24/25, 25, 26, 27, 28)

a. = above, b. = below, l. = left



A room with a view: From the top floor of the DFG head office in Bonn one enjoys a scenic view of the Rhenish low mountain range, the Siebengebirge, and the adjacent Science Centre.