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ORGANIC ANIMAL HUSBANDRY RESEARCH AT THE FEDERAL AGRICULTURAL RESEARCH CENTRE OF GERMANY (FAL)

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Abstract

Organic Animal Husbandry is one of the major scientific tasks of the Federal Agricultural Research Centre of Germany (www.fal.de). The FAL is a research centre under the jurisdiction of the German Federal Ministry of Nutrition, Agriculture and consumer protection (www.bmelf.de).

In 2000, the Institute of Organic Farming (www.oel.fal.de) was founded to establish and carry out high quality research in Organic Animal Husbandry. The Institute is located in northern Germany close to Hamburg and has an own experimental station with 100 dairy cows, 70 dairy goats, 30 dairy sheep, 50 sows, 100 beef cattle and 250 ewes. The experimental station is certified by the EU-organic regulation 2092/91/EEC. Modern laboratory and technical equipment does guarantee a high level of research. Between 60 and 90 people do work in the Institute. The research is based on a holistic approach. The system orientation requires interdisciplinary approaches. Scientist from following disciplines work together: soil science, plant production science, ecology, animal science, veterinary, chemistry, economy and sociology in following work areas:

Organic Dairy Livestock (cows, sheep, goats)

The goal of research in this work area is the optimisation of keeping and feeding dairy cows as key factors for animal health and high milk yield and quality.

Primary questions:

- Special characteristics of the interchange between feed/feeding, animal health, performance and milk quality with particular regard to the protein supply in legume crop sequences
- Studies on labour quality in organic dairy cattle/sheep/goats keeping and possibilities for improvement
- Improvement in organic calf/lamb/kids raising

Organic Sheep and Beef Cattle Keeping

The goal of the research in this work area is the further development of pasture emphasising sheep and beef cattle keeping in regard to hygiene management, with a particular emphasis on infection with endoparasites and which, at the same time, maintains and promotes biodiversity.

Primary Questions:

- Development of organic processes to control endoparasite infection
- Improvement of natural protection in the organic pasture farming
- Studies on the influence of feed quality on the quality of beef and mutton
- Evaluation of improved animal keeping systems on work quality

Organic Pig Farming

The goal of research in this work area is the development of a closed chain in the animal and environmentally appropriate

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organic pig keeping with particular consideration of the meat quality.

Primary questions:

- Studies on the improvement of animal and performance appropriate feeding with farm-own feed
- Development of ecologically acceptable pasture keeping practices with special attention to parasite control and soil and water protection
- Studies on ecological stable keeping of pigs with particular attention to animal appropriateness and work quality

Recent projects

Working area Organic Dairy Farming (cattle, sheep, goats):

- Investigations on milk ability of suckling cows
- Investigations on electrical conductivity of ewe's milk for monitoring of udder health in dairy sheep
- Investigations on the persistence of coagulase-negative staphylococci in goat milk
- Methods for differentiation of organic and conventional produced milk?
- Effects of feeding of species-specific or non-specific milk on development of kids and lambs

Working area Organic Pig Farming

- Testing of tissue development, fattening and carcass performance, meat quality, and breeding suitability of different pig genotypes for organic pork production
- Diminishing piglet losses: Effects of a prolonged suckling period on the constitution of weaned piglets
- Use of *Camelina sativa* oilcake in organic feeding of monogastric animals (model broilers)
- 100 % organic fed stuff for monogastric animals (model laying hens)
- Assessment of grain legumes and oil crop expeller for 100 % organic feeding rations for monogastric animals

Working area organic lamb, kid and beef production

- Health and nutritional effect of shrubs in sheep and goat diet
- Evasive grazing management as a tool for fighting the endoparasitic burden in goats
- Assessment of different old and endangered sheep breeds in low input organic farming systems (landscape management model)

The paper will give an overview of main scientific questions in organic animal husbandry in Germany, the challenges and difficulties of interdisciplinary research in organic farming and will present results of selected projects.

Introduction

The Institute of Organic Farming was founded as the tenth institute of the German Federal Agricultural Research Centre on December 5, 2000. The research of the Institute of Organic Farming is based on a holistic approach to organic farming with an emphasis on organic animal husbandry.

Research focused relatively late on organic animal husbandry. Deficits in scientific knowledge can be found in the fields of animal welfare and health; product quality of milk and meat; meat and milk processing; farm economics; marketing strategies and environmental impact. The research tries to reduce these deficits in the following systems:

- Organic dairy cattle farming
- Organic pig farming
- Organic sheep and goat farming

Table 1: Disciplinary tasks in the working areas

	ORGANIC DAIRY LIVESTOCK KEEPING	ORGANIC SHEEP AND BEEF CATTLE KEEPING	ORGANIC PIG KEEPING
Fodder and Feeding	- farm grown fodder - organic feedstuff quality		
Nutrient cycles and energy flows	- nutrient cycles and energy flows in organic animal husbandry - ground water protection in pasture farming		
Animal Health	- Udder health - young stock health	- endoparasites control	
Milk production and quality	- milk production and milk quality - young stock raising		
Meat production and quality	- appropriate breeds	- meat yield and quality in beef, mutton and pork	
Product quality (chemistry)	- quality of organic feedstuff - quality of organic milk and meat		
Nature protection	- biodiversity in organic pastures - livestock genetic resources for biotope maintenance		
Labour and career relationships	- work quality in animal husbandry		

The goal of the institute is to conduct interdisciplinary research (Table 1) to scientifically support the development of organic animal husbandry to improve the regulations for organic farming (for example, Reg. 2092/91/EEC). Currently about 20 scientists do work at the institute.

The research takes place on-station on a 600 ha experimental organic farm in Trenthorst (close to Hamburg in Northern Germany) and also on-farm throughout Germany. The experimental farm is a contiguous flat land area in hilly East Holstein. The quality of the soil and farming conditions can be classified as very good. Average rainfall is 740 mm per year, the sun shines 1566 hours per year and the average annual temperature is 8.7 degrees Celsius (Figure 1 below).

After two years of conversion the experimental farm became certified as organic farm in 2003. The farm is divided into five independent individual model farms, three with animals and two without animals. The size and structure of the farms is organized like practical farms. All model farms have an own six-part crop sequence. Here cultivated plants are grown which are needed by the model farm.

- The dairy farm occupies 100 hectares and maintains 100 cows, including for reproduction. A modern dairy barn for the housing of two different cow breeds was built in 2004.
- The pig farm occupies 70 hectares and has a herd of 50 sows, including piglet raising. Fattening pigs are kept as necessary. The stables for piglet production were established in 2005.
- 200 sheep and 100 goats are kept on the 107 hectare mixed farm. 70 goats are milked.

Depending on the time of year and the research projects, between 100 and 200 lambs are kept for research experiments during the summer. A large barn is available for the animals. A modern milking parlour is available.

- On one 30 hectare farm, no animals are kept and no manure distributed. The crops harvested are sold at market. This farm simulates a small arable crop farm without animals.
- Similarly, on a 200 hectare farm, no animals are kept. Here, too, the market crops are sold directly. This farm simulates a large non-animal arable crop farm.
- An additional 80 hectares of forest are also available.

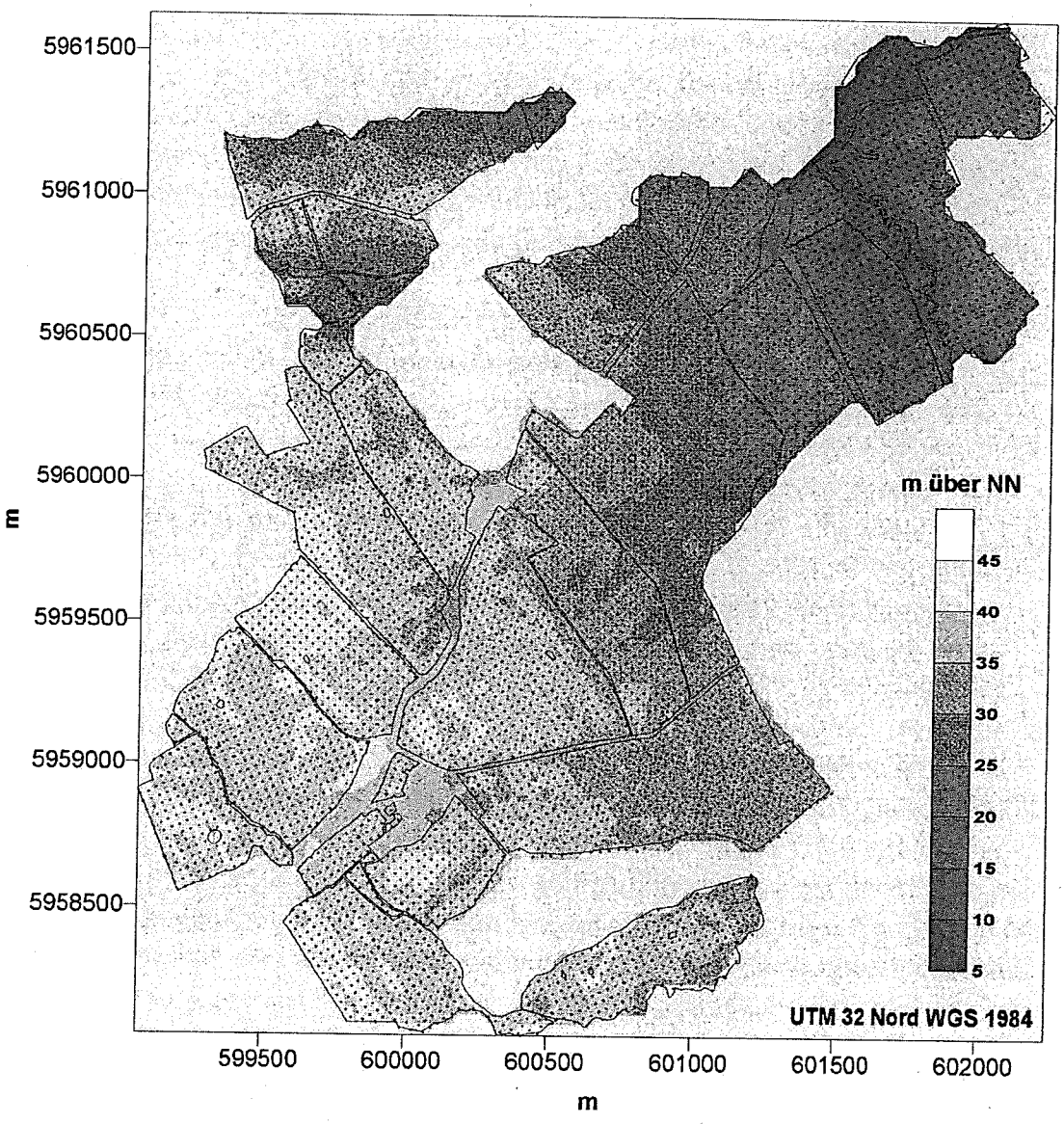

Figure 1: The 600 ha organic research station in Trenthorst shows the altitude of the site above sea level (digital map)

Working Area 1: Organic Dairy Cattle Farming

Dairy cattle play an important role in organic farming. On many organic farms milk is an important factor and has a significant impact on farm income. Problem areas in organic dairy

cattle keeping are non-adjusted nutrient supply (for example, inadequate energy supply in basic feed rations for high performance animals), factor diseases (for example mastitis, hoof diseases, reproductive disorders) and the resulting high remounting rate as well as ethologically suspect practices (for example, raising animals without mothers).

Research emphases of the Institute of Organic Farming include, therefore, improvements in basic feed rations, in preventive health management and in animal appropriate husbandry practices, without forgetting the requirements of natural and environmental protection, of labour quality and economics.

The goal of research in this work area is the optimisation of the keeping and feeding of dairy cows as key factors for animal health and high milk yield and quality.

- Special characteristics of the interchange between feed/feeding, animal health, performance and milk quality with particular regard to the protein supply in legume crop sequences
- Studies on labour quality in organic dairy cattle keeping and possibilities for improvement
- Improvement in organic calf raising

Recent research projects are:

- Investigations on milkability of suckling cows
- Methods for differentiation of organically and conventionally produced milk
- Cows with horns in modern stables
- Calf rearing with mother suckling in dairy barns
- Prevention of resistance of endoparasites against anthelmintics in organic dairy herds
- Milk quality and milk production of different dairy cow breeds
- Roughage focused milk production
- Mastitis prevention with optimized milking and herd management
- Precision dairy cow management in organic farming

Example 1: Mother suckling calves in dairy herds: ethology and health

Mother related suckling is used in suckling cow herds for beef production. Suckling by mother can have a positive impact on ethology (mother-calf relationship) and calf performance and health. There is no knowledge about the impact on intensive dairy herds (Holstein Friesian). Main difficulties are the high milk yield of the cows (udder infection), the milking routine, the stable construction and the calf rearing measures. If calves are allowed to suckle their milk directly from their mothers, better health status can be expected when these calves become mothers themselves. The parameter is udder health.

Since 2005 (two years (2003-2004) after adapting the dairy herd, the dairy barn, the technology and the management towards the targets of the research) selected calves (female, reproduction) are permitted to suckle by their mothers for about three months till weaning. Calves which are not allowed to suckle are used for control. Cow performance, udder health, milk yield, calf health and calf performance are monitored on a regular basis. Preliminary results show that there is no danger to udder health. After suckling the Somatic Cell counts go down to acceptable levels. The calves consume an immense amount of milk (up to 20 litre of milk per day, 100% more than needed).

Working Area 2: Organic Pig Farming

Until now there have been severe problems with organic pig farming. The increased and not saturated demand for organically produced pork has motivated organic farms to build up or expand this farm area. Here, practices from conventional pork farming have been adapted to a large extent because organic practices have not yet been defined. It can be stated that pigs are on organic farms but very often they can not be called organic. Animal behaviour, health, product quality and economics are of major constraints. Farm produced 100%-organic feeding regimes, adapted breeds, drugless health care, high carcass qualities and sufficient income through innovative marketing strategies have to be developed. The overall process chain in organic pig farming has to be developed and integrated in organic farming. The goal of organic pig farming is a closed process chain from piglet production through to the finished fattening pig.

The goal of research in this work area is the development of a closed chain in animal-and environmentally-appropriate organic pig keeping with particular consideration of the meat quality and health parameters.

- Studies on the improvement of animal- and performance-appropriate feeding with farm-own feed
- Development of ecologically acceptable pasture keeping practices with special attention to parasite control and soil and water protection
- Studies on ecological stable keeping of pigs with particular attention to animal appropriateness, hygiene and work quality

Recent research projects include:

- Testing of fattening and carcass performance, meat quality as well as breeding suitability of different pig genotypes for organic pork production
- Diminishing piglet losses: effects of a prolonged suckling period on the constitution of weaned piglets (improved immunity status)
- Assessment of grain legumes and oil crop expeller for 100 % organic feeding rations for monogastric animals
- Prediction of ingredients of local legumes by near infrared reflectance spectroscopy (NIRS)

Example 2: 100% organic rations for monogastric animals

The Institute tries to develop oil plants in organic farming to improve feed rations for monogastric livestock with oil cake. Oil cake is considered an excellent source of high quality protein (Table 2). The problem is the difficult cultivation in organic farming (pest control, productivity) and secondary plant compounds as anti-nutritive factors (ANFs). Rape seed produced from the double low (00) glucosinolate species may only be incorporated in poultry rations at small concentrations (no more than 10 % in DM for laying hens and 5 % in DM in broiler starter rations (8 % in broiler finisher rations). This is because of egg taint problems and off flavours in poultry meat caused by the presence of ANF's in rape seed. Animal do not like bitter ingredients (alkaloids), tannins, etheric oils. Some ingredients are toxic or have negative effect on product quality (e.g., vicine, convicine, sinapine, glucosinolate). For example, to avoid fish smell in eggs a maximum of 100 mg sinapine per kg feedstuff is targeted. Another point is the taste of the feedstuff: Flax expeller is excellent as feedstuff, but, chickens refused flax expeller in feed rations and reduced feed intake from 135 to 60 g per day.

TABLE 2: CRUDE NUTRIENTS AND ESSENTIAL AMINO ACID CONTENT IN ORGANIC FEEDSTUFF FOR LAYING HENS: WHEAT, EXPELLER AND LEGUME SEEDS (IN % DM; PRODUCED IN TRENTHORST, NORTHERN GERMANY)

	WINTER WHEAT	FLAX EXPELLER	RAPE EXPELLER	SOYBEAN EXPELLER	BLUE LUPINE SEEDS	COMMON VETCH SEEDS
Ash	1,5	5,7	5,9	6,2	4,5	6,4
Crude protein	11,4	38,3	32,4	45,3	36	32,6
Crude fibre	2,9	9,4	11,3	5,5	16,8	5,6
Crude fat	2,4	8,8	18,7	13,7	5,4	2
Sugar	2,3	4,2	8,8	8,8	3,3	5,3
Starch	71,3	8,5	6,1	4,9	11,3	39
MEtotal (MJ / kg)	14,8	10,8	13,6	13,7	9,8	12,9
Methionine	0,08	0,77	0,68	0,72	0,21	0,21
Lysine	0,29	1,41	1,88	2,57	1,21	1,32
Cystine	0,2	0,72	0,86	0,75	n.d.	n.d.
Tryptophan	0,06	0,38	0,17	0,4	n.d.	n.d.

Of the grain legumes, peas are among the poorest in protein and lupines the richest. The crude protein proportions increase in the sequence peas (about 25 % in DM), faba beans (28 %) and lupines (yellow lupines 44 %, white lupines 39 %, and blue lupines 34 %). Nevertheless, the blue lupines are suitable for organic farming because they can be cultivated without the risk of anthracnosis (*Colletotrichum lupini*). Lupines have crude protein content similar to that of full fat soy beans. The lysine content is high and the methionine + cystine content is moderate. The quality of blue lupines as a feed ingredient is variable. Lupines, especially the white lupines, have a higher fat content than beans or peas. The proportions of saturated fats are relatively low at approx. 20 %.

Peas are the most important ingredient for organic poultry rations to replace soy beans. For layers, 25 – 30 % in DM and for broiler 15 – 20 % in DM is possible. Sweet lupines can be taken as well, but not more than 20 % in DM. However, due to wide variation between lupine cultivars and in the treatment of raw materials, and therefore in their nutrient analysis, it is not possible to provide definitive universal recommendations. Beans do not appear to be a good alternative protein source for use in organic poultry rations. This is because of the low concentration of sulphur amino acids and the presence of ANF's.

Processing of feedstuff

Digestibility is not same as availability. Digested and absorbed amino acids are not completely available for protein synthesis. For example, thermally damaged amino acids are digestible and absorbable, but not effective. With thermal treatment, the sinapine content of organic rape expeller could be reduced from 14,800 mg to 266 mg per kg DM. Therefore, colza cake has to be treated in order to become a feedstuff for laying hens (maximum 27%).

Hydrothermically treated lupines increase the amount of ME from 14.92 to 15.08 MJ / kg, the rumen undegradable protein (UPD) from 20 to 45 % (UDP5 from 73 to 262 g/kg CP and UDP8 from 88 to 310 g/ kg CP) and nXP values from 196 to 245 g / kg.

Working Area 3: Organic Sheep and Goat Farming

In Germany, extensive lamb production is often correlated with nature conservation and biotope management. Restrictions for animal grazing on protected biotopes are above the guidelines of organic farming: e.g., no concentrate feedstuff while grazing, no melioration of grassland and low quality of roughage (standing hay). The quantitative and qualitative production performance of these animal husbandry systems is low (low input low output systems). High economic output is possible with milking of sheep and goats in intensive systems. Udder health, milk quality and hygienic management have not been not explored and defined for organic farming as well as for conventional farming.

The goal of the research in this work area is the further development of pasture related sheep and goat keeping which, at the same time, maintains and promotes biodiversity and regards the small ruminant milk quality and production and hygiene management, with a particular emphasis on mastitis and infection with endoparasites.

- Assess milk quality and milk production in organic sheep and goat farming
- Development of organic processes to control endoparasite infection
- Improvement of natural protection in organic pasture farming
- Studies on the influence of feed quality on the quality of beef and mutton
- Evaluation of improved animal keeping systems on work quality

Recent research projects are:

- Investigations on electrical conductivity of ewe's milk for monitoring of udder health in dairy sheep.
- Investigations on the persistence of coagulase-negative staphylococci in goat milk
- Effects of feeding of species-specific or non-specific milk on the development of kids and lambs
- Health and nutritional effect of shrubs in sheep and goat diet
- Grazing management as a tool for fighting the recurrent endoparasitic infection in goats

Example 3: Biological control of Gastro-Intestinal-Nematodes (GIN)

In organic farming, infection of grazing ruminants with gastro-intestinal nematodes (GIN) is an important factor influencing animal health status. Subclinical helminth infections have resulted in up to 40% depression in live weight gain and a 6-30% reduction in food intake by lambs. Wool production has been reduced by 40% and milk production by 15% in parasitized sheep. Parasite control in sheep and goats over the past 30 years has been achieved almost exclusively by the use of proprietary anthelmintics and resistance of nematodes against those drenches has been reported world-wide.

Research on D. *flagrans* had demonstrated to have the potential of a biological agent by catching the larvae of endoparasites by constructing sticky trapping nets in the dung pad. The spores of nematophagous fungi are robust in the stomachs and gut. By feeding the spores each day, every dung pad contained spores ready to work.

On 4 comparable pastures, 40 first and second-year- grazing goats and sheep were fed

additionally daily with 500.000 spores/kg BW D. *flagrans* for 3 months; another 40 were kept as control. Every 2 weeks all animals were monitored during the whole pasture season concerning GIN-egg output und BW.

Only the first-year-grazing goat-group developed a significant better Body Weight Gain (15,4 kg versus 11,9 kg, $p<0,05$). No effects in sheep and second-year grazing goats. The GIN-egg-counts of goats differ significantly ($p<0,01$) at the end of the feeding period [1235 (⊠518) eggs/g faeces versus 517 (⊠654) eggs/g faeces]. But 2 weeks later no significant difference was found. Comparable results were found within sheep. The feeding groups needed less curative treatments and seemed to keep a better visual body condition.

But the effect of feeding D. *flagrans* remained poor. Probably heavy rainfall inhibits the development of trapping nets in dung pads. And the application should perhaps better be done by a releasing device (bolus). Further research is necessary.

The use of tanniniferous plants as forage crops is probably another option of an integrated control strategy against GIN. Condensed tannins protect dietary nitrogen from rumen degradation by microorganisms and ameliorate protein supply in ruminants with positive effects on growth, wool production and milk yields. Furthermore, CT's prevent rumen bloat in grazing ruminants. In order to implement tanniniferous plants into a control strategy against GIN, they have to be adapted to local conditions. In several field studies, it has been difficult to relate antiparasitic effects to the actual amounts of CT. The objectives of the research with bioactive plants are to determine the amount of CTs in shrubs, their effect on growth and control of GIN in sheep and goats. Shrubs are an excellent source of tannins and other important ingredients for small ruminants. Shrub browsing is beneficial to goat and sheep welfare and has probably positive impacts to animal health. This is not known. At the institute the local shrubs are analysed for their growth and anthelminitic effects to goats and sheep. Recent findings are promising but not validated to be published scientifically. But it shows the need and the sense of new strategies to prevent and control GIN, not only in Organic Farming. This takes time and a lot of efforts.

Overlapping Activities

Some scientific questions are relevant for all organic animal systems. The organic farms without animals need different strategies and emphases for production and management.

Recent research projects are:

- Nutrient and heavy metal contents of organic farmyard manure (Germany-wide panel)
- Use of biological-dynamic preparations in organic wheat production
- Cultivation of oilseed crops in organic farming (rape, flax, false flax)
- Energy autarky of organic farms without space demand (power, heat and fuel)
- Mixed crops cultivation technique (optimizing yields, plant health and weed control)
- Plant oil fuel technology for tractor engines
- Rural communication
- Animal health plans – sociological and veterinarian assessments
- Optimising of potato production in organic farming regarding the processing to potato

chips (US: French fries) and potato crisps (US: chips)
- Long term monitoring of soil fertility, of nutrient supply, of yield parameters, of quality of plants and of biodiversity in an organic farm
- Validation of complementary and holistic measurements to evaluate food qualities

About the Author

Gerold Rahmann has been Head of the Institute of Organic Farming of the Federal Agriculture Research Centre of Germany in Trenthorst, Westerau since 2000. He has published 13 books and 150 papers, 25 of which were peer reviewed. His childhood was spent on his family's dairy farm in Ostfriesland, Germany.

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