SPATIAL SEPARATION AND ANALYSIS OF DENSELY AND SPARSELY POPULATED LIVESTOCK AREAS USING GIS TECHNOLOGY

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This paper presents the results of a project which focuses on the geographic separation of different spatial densities of European livestock areas. It is a part of the European Community (EC) project "Development of prevention and control strategies to address animal health and related problems in densely populated livestock areas of the community" (FAIR CT 97-3566). For the spatial analysis, Geographic Information Systems (GIS) were used. A GIS is very powerful tool for managing, analyzing and visualizing spatial data. Its capabilities, however, have to be modified and extended to address the needs of modeling and simulating spatial patterns of epidemiological risks in livestock. The main target of the project is to generate a user friendly GIS shell for the veterinary administration. This tool will enable the user to define, locate and separate densely populated livestock areas (DPLA) in the EC. First investigations consider only pigs but the techniques can be applied to other animals as well.
The spatial separation of DPLA's is very critical because strategies for fighting animal diseases such as classical swine fever (CSF) depend heavily on the density of pigs in a region. Circles with appropriate radiuses (depending on the risk factors) will be drawn around the location of the outbreak. In these circles, restrictions will be imposed ranging from killing the animals in the inner circle to prohibiting trade in the outer circle. The radius of the circle will depend strictly on the structure of the affected region. In a later stage natural boundaries and weather aspects will be incorporated in the GIS analysis, especially for the risk analysis of diseases which can also be spread through the air.

Materials and Analysis Methods

The most common way to identify the density for a region is to calculate the ratio (RA) between the number of pigs and the area of an administrative unit (e.g. a community). In our analysis, for example, 18 of the 32 inspected communities in the German study area in the Northwest of Lower Saxony have a density of more than 300 pigs/km² (fig. 1). A density of more than 300 pigs/km² has been found to be a useful threshold for the declaration of an epidemiological risk area.

Table 1: Differentiation scheme

	pigs/km²
sparsely populated lifestock area (SPLA)	0 – 50
midsize populated lifestock area (MPLA)	> 50 – 300
densely populated lifestock area (DPLA)	> 300

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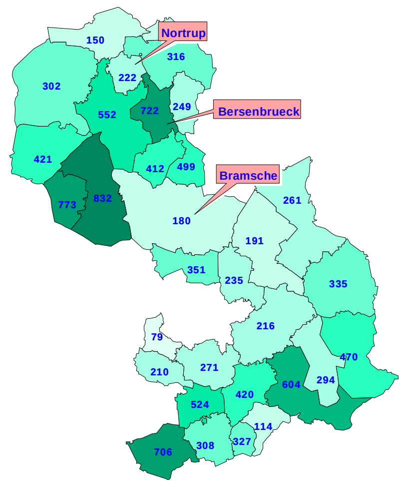
Fig. 1: Pig density (pigs/km²) at community level for the county of Osnabrueck (data from 1998)



By analyzing the spatial distribution of farms in the communities with less than 300 pigs/km² one can detect a number of clusters and clumps of concentration in these regions. As a statistic measurement for such concentrations, the Nearest Neighbor Index (NNI) was implemented in the GIS. Using the NNI the spatial distribution pattern can be expressed with the associated 'R' value. For an example, the community 'Bramsche' has an overall density of about 180 pigs/km² which is a midsize populated area. The NNI for this region, however, provides an R value of 0.81 which indicates a strongly clumped distribution pattern. Some farms are very close to each other, which leads to densities of more than 4,800 pigs/km² in some areas of this MPLA.

This example demonstrates that the RA value at the community level alone is not a sufficient measurement tool for locating DPLA's. Other methods for the assessment of epidemiological risk areas have to be applied. One way is the interpolation from points into an area by generating a regular raster with a grid size of 1 km² (Logley and Batty 1996). The numbers of pigs in every grid cell were summarized yielding a better differentiated pattern than the standard RA value. This method, however, may lead to some spatial uncertainties especially when grid cells with low densities adjoin others with high densities. Using a raster with smaller grid sizes, this uncertainty can be minimized to the desired spatial resolution level.

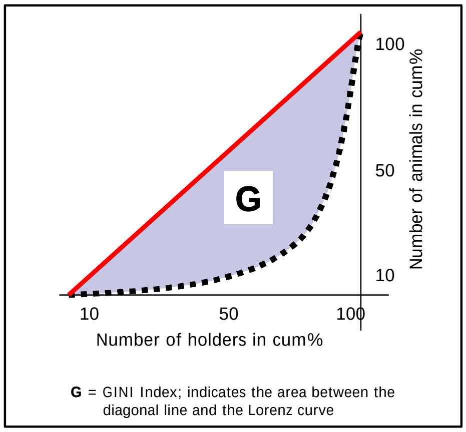
By using a special tool of the veterinary GIS shell, one can check the number of animals within a given circle around every individual farm. Using this approach, an individual density value (RAm) can be assigned to every farm. Using a 1 km² circle, for example, we found densities of more than 8,000 pigs/km² in our study area.

In a next step, these very densely populated areas were analyzed regarding to the size of the herds and the number of farms. The first analyses lead to the presumption, that –not surprisingly- farms with the largest amount of pigs are located in the most densely populated areas.

Results and GIS Implementation

A special GIS shell tool was designed to calculate the GINI index (GI) and plot the results as a 'Lorenz curve'. Lorenz curve features can be summarized as follows: If the distributions are equal (e.g. 10% of the animals belong to 10% of the farms), the Lorenz curve is a straight line with a linear increase from 0 to 100% (fig. 2, solid line). In case of a strongly unequal distribution (e.g. 50% of the animals belong to

Fig. 2: Lorenz curve und GINI index (G)



10% of the farms), the Lorenz curve displays an exponential behaviour (fig. 2 dotted curve).
Fig. 3 and 4 present a comparison between the two communities with the smallest and the largest GI. The GI of 0.31 for Bersenbrueck indicates a very unequal distribution. The plotted Lorenz curve for Bersenbrueck shows 50% of the holders have only about 5% of the pigs. Otherwise nearly 10% of the holders have about 50% of the pigs (fig. 3). In the community Nortrup (GI = 0.52) 50% of the holders own 16% of the animals and

Fig. 3: Plotted Lorenz curve and GINI index for the community Bersenbrueck

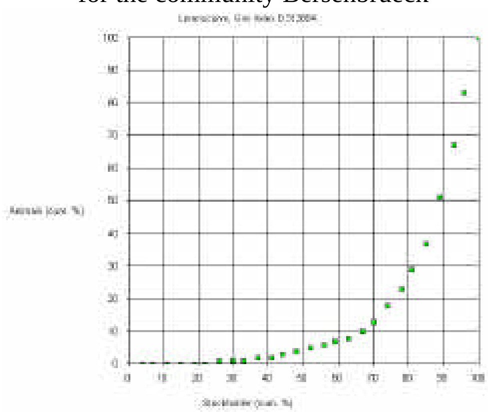
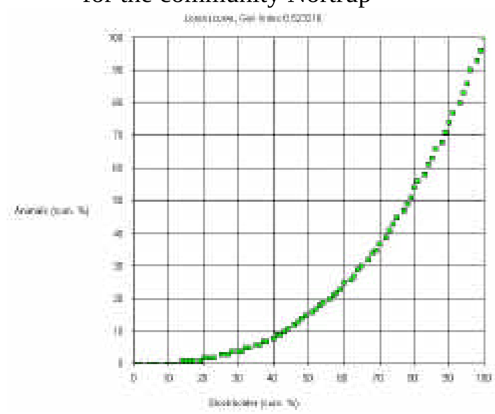


Fig. 4: Plotted Lorenz curve and GINI index for the community Nortrup



10% have about 22% of the pigs. There is a strong tendency towards an unequal distribution in all communities of the county (see Windhorst 1992). The GI for the whole county with its 32 communities has an overall standard deviation of 0.06, which indicates a very uniform pattern.

Discussion

A more realistic risk index for the communities is being developed in a combination of the presented methods. First analyses show a correlation between the Ram and the GI values of 0.58. This will be investigated in the next future.

References

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Windhorst, H.-W. (1992): Die Konzentration in der Veredelungswirtschaft nimmt weiter zu (I) – Schweinehaltung; in: ISPA Mitteilungen, N° 7, Vechta.