Phase transitions in stigmergic territorial systems

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When animals rely on processes external to themselves, they may coordinate their activity in an indirect manner. If the space retains memory of the passage or activity of an individual, animals respond indirectly to one another because interaction is mediated by the environment. This phenomenon, called stigmergy was coined by Pierre-Paul Grass in the '50s to explain nest building in termites. Besides the collective coordination in complex tasks, stigmergic processes may also serve the purpose of directing individuals towards or away from certain regions of space. Avoidance behaviour, specifically eschewing marks deposited by others, is the behaviour with which territorial patterns of various vertebrates form. Spatial segregation in minimally overlapping regions is accomplished by individuals leaving their own marks wherever they go, while retreating upon encountering foreign ones. Depending on the population density and the time for which the scent remains active after deposition, radically different population patterns may emerge from one extreme with territories that are highly mobile and possess hugely variable shapes to the other extreme with territories that are nearly static and tessellate the terrain in an hexagonal fashion. An analysis of the proper order parameters shows that by increasing population density phase transitions in the spatial arrangement of the territories transform the system from a gas to a liquid and ultimately to a solid.