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Aggregation in *Agonum dorsale* Pp. (Col., Carabidae)

By J. Muggleton

The report of an aggregation of *Agonum dorsale* Pp. on Holy Island, off the Northumberland coast, by Benham (1969), raises again the need for a satisfactory explanation of winter aggregations in this species. Such aggregations have been reported on several occasions and these reports are summarised by Greenslade (1963a) in a list of aggregations in the British Carabidae. I have recorded aggregations of *A. dorsale* at Staines, Middlesex (Muggleton 1966, 1968). However, there does not appear to be any information available on the factors which stimulate the formation and dissolution of these aggregations and it will be worthwhile considering what these may be.

Greenslade (1965) gives the time of emergence of the adults as August and September and it seems probable that the beetles immediately seek shelter under various objects giving them protection against dessication and predators during the daytime. Herrström (1949) showed that when given the choice between sunlight, half shade and full shade, *A. dorsale* chose full shade. Therefore the beetles are negatively phototactic and this must be their primary motivation in seeking shelter under various objects.

The factors controlling the formation of the aggregations fall into two classes. Firstly there are those factors which determine when an aggregation first appears and secondly there must be those factors which induce the beetles to come together in aggregations. At this point it is important to note that the beetles do not enter diapause, but remain active throughout the period of aggregation and will scatter in all directions directly the object they are sheltering under, is lifted.

At Staines a record of the first appearance of the aggregation was made in 1965 and 1967. In 1965 it happened on 12th December and in 1967 on the 2nd September. The factors influencing the timing of aggregation may be either seasonal or biological. The small amount of evidence, given above, of variation in the timing of the first appearance of aggregation would appear to rule out seasonal changes (e.g. temperature and photoperiod) as the factors responsible for the timing. Biological controls, such as an internal timing factor, would also appear to be ruled out.

However, more information is needed, on the dates on which aggregations first appear, before a definite conclusion can be reached. At the moment I would favour another form of biological control which has been put forward by Penney (1969) for the control of summer diapause in *Nebria brevicollis* Fab. Penney suggests that the summer diapause in *N. brevicollis* may be induced when the fat content of the body reaches a critical level. A similar explanation would fit in with the activity of *A. dorsale*, thus the beetles may not enter their hibernation quarters until they have built up sufficient internal food reserves. From observations at Staines, the initial build-up of the aggregation is a fairly rapid process, although the numbers present vary throughout the winter.

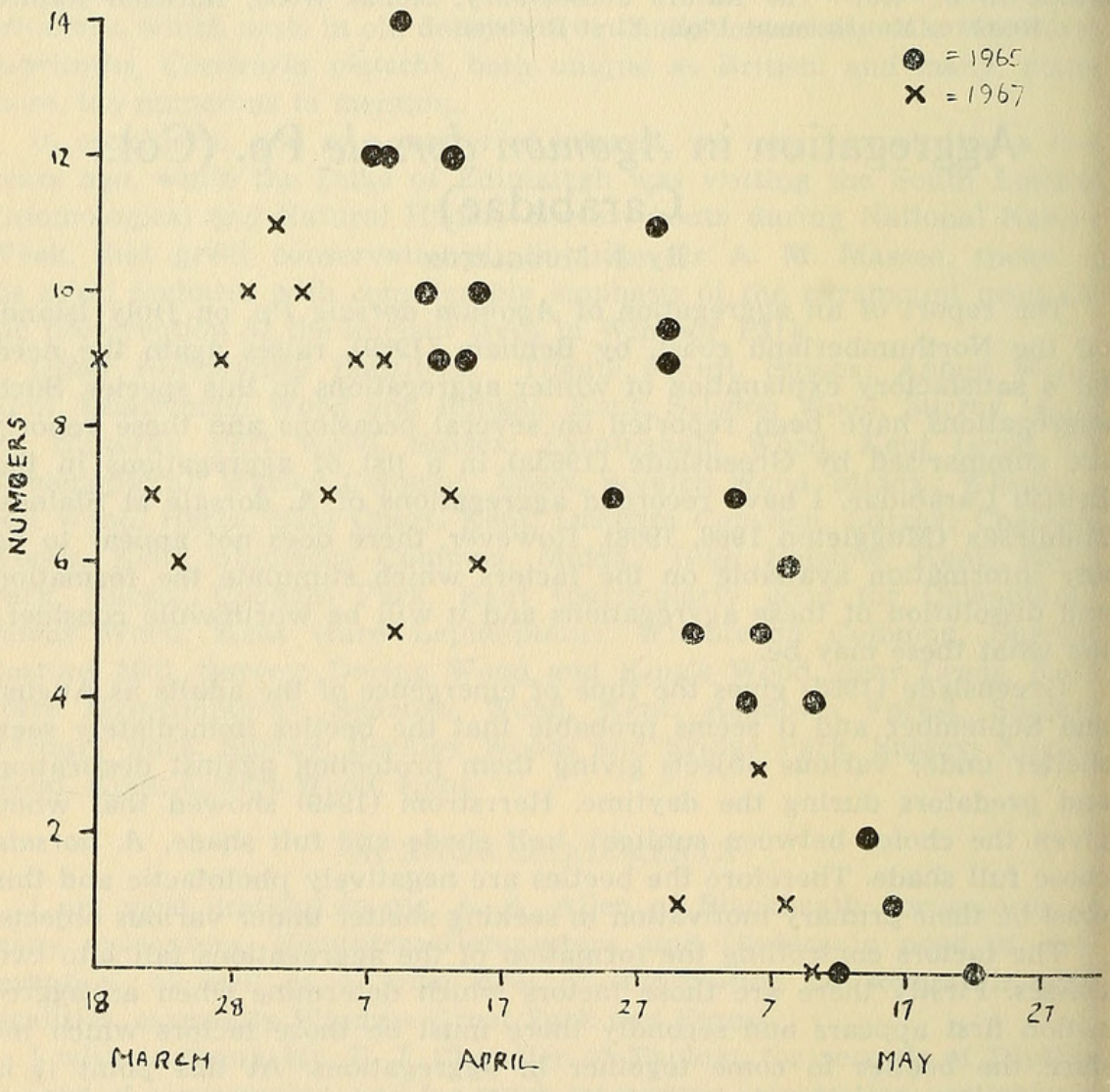

FIGURE 1.—Numbers of *A. dorsale* aggregated under a stone at Staines, from mid-March to May in the years 1965 and 1967.

Assuming that conditions are correct for the formation of an aggregation, we must now consider what further factors act to bring the beetles together into aggregations. It is possible that some selective advantage may be gained from the aggregations. Two possibilities suggested by Greenslade (1963b) are that excessive transpiration may be reduced in an aggregation (by the production of a localised area of high humidity) or that the aggregation may keep the sexes (here, I would substitute popula-

tion for sexes) together until mating can take place. A further possibility is that the green and orange coloration of the beetles constitutes a warning coloration which is made more effective by a large number of individuals. What mechanisms could be responsible for bringing the beetles together? Greenslade (1963b) shows that activity in *N. brevicollis* appears to be inhibited by a pre-existing aggregation. Thus a beetle will move from one uninhabited stone to another, until it comes into contact with other individuals, at which point it will stop. This could apply to *A. dorsale*. Another possibility is that the beetles emit a scent which attracts other individuals of the same species. A third possibility is that the beetles have a very specific requirement for their hibernating site and that this brings all the beetles in one locality together.

Alternatively aggregations may have no selective advantages and may be attributable *solely* to the scarcity of suitable hibernating sites. This has been suggested for aggregations in other members of the Carabidae by Greenslade (1963b), although he thought it may not apply to *A. dorsale*. Benham (1969) has suggested that it may be the reason for aggregation in *A. dorsale*. At Staines the aggregations occurred under the same stone from 1965-1968 (no aggregation had appeared under this or any other stone up to the beginning of February 1969) although there are plenty of other stones nearby. This supports the idea that the beetles need a highly specialised environment in which to hibernate. I can think of no other reason why they should return to the same stone. This stone is sheltered by a piece of tin and therefore the ground beneath it is drier than under the other stones. It is on a slight north-facing slope and during the winter does not receive so much sun as the other stones. It is also the last place from which snow clears. From March to May 1967 the temperature under the stone at the times the aggregation was counted, ranged from 10°F. above the shade temperature to 7°F. below the shade temperature. It was on average 1·5°F. higher than the shade temperature. Whether scarcity of habitats is the sole cause of aggregation or whether it is the mechanism that has evolved to produce a selectively advantageous aggregation is a question which cannot be answered at this stage.

The dissolution of the aggregation is a gradual process. This is shown in Figure 1, which gives the number of beetles in the aggregation at Staines from mid-March until the end of May, in the years 1965 and 1967. It can be seen that the aggregations followed the same pattern in both years (a similar pattern occurred in 1966, only with fewer individuals). This suggests that the dissolution of the aggregation is determined by seasonal changes such as temperature, humidity or photoperiod. It can be seen that as well as the gradual decrease in the numbers in the aggregation, there is a day to day variation in numbers. This implies that the beetles leave the stone during the period of aggregation and then return. Thus the beetles are not always under the stone and could be influenced by photoperiod at this time. The day to day variation in numbers is not directly related to temperature, but is likely to be related to humidity. However, the process of dissolution may be related to the gradual increase in temperature from March to May. On the other hand dissolution could be under some kind of inherent biological control. Other possibilities are that it could be controlled by depletion of food reserves or by the maturation of the gonads.

The pattern of the build-up of the aggregation under the stones and its gradual dissolution closely follows the behaviour of the population of *A. dorsale* studied by Pollard (1968). He found that the beetles overwintered in a hedge bottom, but although large numbers of the beetles were found he did not see any aggregations (pers. comm.). It is probable that, when or where conditions are not suitable for the formation of aggregations, the beetles are able to overwinter successfully without forming an aggregation. Pollard (1968) found that during May there was a gradual dispersal of the beetles from the hedge to a neighbouring field, where breeding took place. In a similar manner the dissolution of the aggregations under the stone is followed by dispersal to other stones, where the beetles can be found in cop.

Summary.

Several factors have been suggested which could be involved in the control of the formation and dissolution of aggregations in *Agonum dorsale* Pp. These factors can be separated under three headings, firstly, those responsible for the timing of the formation of the aggregation, secondly, those factors inducing the beetles to aggregate and thirdly, those responsible for timing the dissolution of the aggregation. I suggest that these are respectively, the build-up of food reserves, the scarcity of suitable habitats, and seasonal climatic changes. This presents a complicated picture which remains to be tested by observations on aggregations of this beetle.

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ORGYIA ANTIQUA L. AT LIGHT. — I can add two more records of the vapourer moth coming to light: Appledore, 14.ix.1954; Sheffield 26.viii. 1965. On both occasions the moths came in early, within half an hour of lighting up and while it was still twilight.—AUSTIN RICHARDSON, Beaudesert Park, Minchinghampton, Glos. 6.v.1969.