Developing Science Observation Skills: Appreciating Acorn Ants

ABSTRACT
Acorn ants (genus *Temnothorax*) are a powerful model organism for illustrating the variety of interactions in an ecosystem. We developed five teaching units with acorn ants as the exemplary insect. The aim of this study was to provide a quantitative and qualitative analysis of secondary school students’ attitudes before and after teaching units. Students (N = 459) from 22 classes participated in the study. Students’ attitudes were measured using a two-stage test design. We investigated the influence of class level, gender, teaching units, and time period of participation on students’ attitudes. Additionally, we surveyed a subsample of students on their learning enjoyment in 10-minute interviews. The findings suggest that students’ previous investigations with insects in science classes had been few. The results indicate an influence of gender, time period, and the autonomous keeping of ants on attitudes toward the social insects. Although no changes in attitudes were observed for students of lower and higher secondary school, students at the intermediate level had slightly higher attitude scores on the posttest than on the pretest. The majority of students evaluated teaching units positively. Our findings suggest that ant research may offer new opportunities for directing students’ attention to native woodland inhabitants.

Key Words: Ants; attitudes; experience; hands-on; insects; learning enjoyment; secondary school; *Temnothorax*.

Introduction
Children’s and young adolescents’ development of evaluation skills is greatly influenced by recurrent contact with nature. Direct experience with natural processes and creatures offers opportunities for discovery, wonderment, creativity, and exploration (Kellert, 2002). However, research points to children’s increasingly symbiotic experience, which mostly occurs through communication technologies, books, or magazines in the absence of physical contact with nature: “many children experience nature through the imagined and exotic rather than through the actual and local” (Kellert, 2002, p. 128). As a consequence of diminished direct encounters in natural settings, children may not be aware of the peculiarities and inhabitants of nearby ecosystems and, consequently, may not develop appreciation for them. Therefore, there is an urgent need for educators to integrate the native flora and fauna into their lessons. Curriculum developers and educational standards stress the importance of hands-on activities with living animals for science classes (National Research Council, 1996; AAAS, 2009).

We have established acorn ants of the genus *Temnothorax* as a new model organism for biology classes, exemplary of the diverse relationships within an ecosystem on the one hand, and of social insects on the other hand. *Temnothorax* species are found on several continents. Examples are the ant species *T. longispinosus* in the United States and *T. nylanderi* in Germany (Holldobler & Wilson, 2008; Figure 1A). Ant research with *Temnothorax* is an exciting endeavor from the start. Each student can individually collect a whole colony in a nearby oak forest. As their name suggests, these ants live in hollow acorns alongside other microhabitats. For students, it is hard to imagine that a whole colony, including one queen, offspring, and 80 to 90 workers, lives inside a single hollow acorn. These ants are easy to collect, transport, and keep, are not endangered species, and pose no threat to human health. A visit to natural sites gives vitality to classroom work for the next few weeks and provides students with opportunities to develop questions and place their investigations in a wider context (Harlen, 2006). Once the ants have moved to artificial nests (Figure 1B) and into the classroom, this organism can facilitate the study of morphology, development, ecology, neurobiology, and animal behavior within the framework of diverse curricular requirements. At the end of research in class, the ants will be provided with new microhabitats from nature (e.g., a piece...
of straw or bamboo) and brought back to the forest. This integral approach allows students to observe ants in their natural habitat (direct experience) and keep them for several weeks in class (indirect experience). Ant research with Temnothorax, therefore, establishes a connection between science education in class and out-of-school learning (Rennie, 2010).

Several studies have shown beneficial effects on students’ attitudes from hands-on interventions with living animals (e.g., Tamir & Shcrr, 1997; Wilde et al., 2012; Klingenberg, 2013), although to our knowledge, there has been no research on students’ attitudes toward social insects in particular. In many of these studies, control groups were taught using videos instead of living animals. In an earlier study of our own (Sammet et al. 2015b), we had found that students were more motivated to work hands-on with living ants or carry out an experiment accompanied by a video, compared with only watching a video. Therefore, in the present study, all students investigated living ants. We compared student groups that differed in the time period spent with ant research. Our aim was to determine variables that influence students’ attitudes, to take these into consideration in future ant research. The integration of living animals in class requires time and energy. It is therefore necessary to determine factors of influence and ensure optimal use, for teachers and students. In particular, we wanted to examine the following research questions: (1) What kinds of experience with ants do students have? More specifically, do they have experience with ants in school, in their leisure time outdoors, or in the media? (2) Do attitudes toward ants change after these teaching units? Which variables (class level, gender, teaching units, or time period) have an influence on attitudes? (3) Do students enjoy the teaching units with ants? In particular, do student groups differ in their learning enjoyment?

**Hands-on Activities with Acorn Ants**

Students (N = 459) from seven different schools, 22 classes, and all secondary-school class levels participated in this study (Table 1). Ant research took between 1 and 6 weeks, depending on the number and choice of teaching units. Supported by several teachers, we developed five teaching units for secondary-school students. To create comparable framework conditions, we provided teachers with lesson plans, student worksheets, and instructions for experiments and tasks via an online platform. Teachers then decided individually which and how many teaching units they would integrate into their lesson plan and conducted the teaching units themselves.

Using Temnothorax as a model organism exemplary of insects, complete teaching units or single modules can be carried out (Table 2). Modules 1, 2, and 4 are mandatory for at least one class per school, while all other units are optional. For reasons of time, some teachers participating in this study preferred to take care of ant colonies themselves and worked with ant colonies from our laboratory instead of instructing their students to collect and take care of ants themselves. While teaching unit 1.1 requires a field trip to a nearby forest, all other units can be conducted inside the classroom. We developed ant research kits that contain all materials for hands-on work with acorn ants. The majority of materials can be purchased or built if research kits are not available. Figure 2

![Figure 1. (A) A worker acorn ant (Temnothorax nylanderi) inside the nest. (B) Artificial nest (10 × 10 cm) for acorn ants.](image-url)
provides insights into selected ant research modules. For further details, see http://www.ants-in-school.com and the online Supplemental Material for this article.

\[\text{Research Design}\]

We used a pretest–posttest design to survey students (N = 459) before and after teaching units with ants. The questionnaire was designed to assess attitudes, prior experience, and learning enjoyment (Table 3; the survey items, originally in German, have been translated for this article). Questionnaires were administered ~2 weeks before and after ant research by each classroom teacher.

Students’ experiences with ants and other insects in school and in their leisure time was assessed using six items (these refer to insects in general, but we speak only of ants hereafter, to facilitate reading). Students evaluated three items (items 1, 2, 4) on a three-point Likert scale (0 = no, 1 = undecided, 2 = yes). In an open-ended task (item 6), no (serious) answer was evaluated by 0, while one or more correct answers were evaluated by 1. Two multiple-choice tasks (items 3 and 5) allowed several answers. We assigned 1 to each choice indicating experience with ants and 0 to missing experience. Total scores may range from 0 to 20.

The reliability (Cronbach’s \(\alpha\)) of the construct “experience” was described by 0.67 (Table 4). Additionally, students were asked to name insects they had already observed in class and describe projects carried out during visits to the forest in open-ended tasks.

Attitudes toward ants were measured by six items. Students evaluated statements (items 8 and 10–13) on a Likert scale (0 = negative attitude; the higher the value, the more positive the attitude). Items 7 and 9 allowed several answers. In these cases, we assigned 0 points to each choice with negative (e.g., “disgusting”) and 1 point to each choice with positive connotation (e.g., “fascinating”). Total scores may range from 0 to 21 (item 13 was left out for total scores for comparability). The reliability (Cronbach’s \(\alpha\)) of the construct “attitude” ranged from 0.75 in the pretest to 0.73 in the posttest (Table 4).

Learning enjoyment was measured using four items. Items 14, 16, and 17 offered a three-point Likert scale (0 = was no fun/do not agree, 1 = undecided, 2 = fun/fully agree). One item (item 15) allowed several answers. Here, we assigned 0 points to each choice with negative connotation (e.g., “disgusting”) and 1 point to each choice with positive connotation (e.g., “exciting”). Total scores may range from 0 to 10. The reliability (Cronbach’s \(\alpha\)) of the construct “learning enjoyment” was described by 0.75 (Table 4). Two closed-ended questions – “Handling ants with tweezers was (a) difficult, (b) undecided, (c) easy, (d) not done” and “Collecting ants in the forest was (a) no fun, (b) undecided, (c) fun, (d) not done” – applied only to a subsample of students who carried out these tasks. Additionally, students were asked to write down unanswered questions. Toward the end of teaching units, we surveyed four students at a time in 10-minute interviews on their learning enjoyment. We used the same questions as in the written survey.
Descriptive statistics were carried out to compare the different variables (class levels, genders, teaching units, and time period). Mean values and standard deviations were assessed for items and total scores depending on the particular participant group. To compare individual items and total scores, we performed a one-way analysis of variance (ANOVA) on the data with the particular participant group as independent variable and scores as dependent variable. We used t-tests to compare individual items and total scores between two participant groups at a time. SPSS version 21.0 was used for statistical calculations.

Figure 2. Examples of modules for ant research with *Temnothorax nylanderi*. 

Box 1: Collecting and keeping (modules 1 and 4)
These modules are mandatory for ant research in class. Since a whole colony of *Temnothorax* ants lives inside a single hollow acorn, students may easily collect their own ant colonies in a nearby oak forest. Afterwards, they prepare artificial nest sites for the insects. As soon as the ants have moved to their new nests, students take care of them at least once a week providing them with water, proteins and honey. At the end of ant research in class, students open the nests and provide ants with natural nest sites. After the ants have moved, students bring them back to their natural habitat.

For further details see www.ants-in-school.com.

Box 2: How strong are ants? (module 8)
In this module, students find out that ants are able to carry many times more than their own weight. Students open the ants’ nest and provide them with fir needles they have weighed in advance. Since the ants are inclined to close their nest for safety reasons, they start to carry the needles into their nest.

For further details see www.ants-in-school.com.

Box 3: Development of castes within a colony (module 12)
The best time for this module is during the course of the spring and summer months. At this time, all developmental stages and castes are represented within the nest. Students compare the different nest members and explain differences in structure and function.

For further details see www.ants-in-school.com.

Box 4: What do ants like to smell, taste, or walk on? (module 14)
In this experiment, students put single ants in an arena to find out their preferences for different smells, food, or substrate materials.

For further details see www.ants-in-school.com.

Box 5: Blue ants: Division of labor in an ant colony (module 15)
Students feed hungry ants with colored honey in this experiment. After some worker ants have fed on the blue honey, they start supplying colony members inside the nest with nutrition. Using stereo microscopes students may observe the gasters’ changing color.

For further details see www.ants-in-school.com.
The majority of students (85.6%) had not yet worked with living ants in school. Almost three-fourths (72.5%) were unable to describe any insects they had observed in class, while 14.2% named concrete insect species. Some students described other animals (7.2%) or insects and other animals (6.1%). In their leisure time, students had encountered ants in many different places. However, 8.1% of students claimed they had not seen ants in any place. Almost three-fourths (73.9%) of students had already seen Table 3. Items in pretests and posttests (*several answers possible; **open-ended task).

<table>
<thead>
<tr>
<th>Experience</th>
<th>1</th>
<th>Have you ever observed living ants in biology classes?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre</td>
<td></td>
<td>a) no – b) undecided – c) yes</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>Have you ever visited the forest with your biology teacher?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>a) no – b) undecided – c) yes</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>Where have you observed ants in your leisure time?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>a) nowhere – b) meadow – c) garden – d) forest – e) room – f) other places</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>Have you already seen different ant species?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>a) no – b) undecided – c) yes</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>Which of the following ants have you already seen in reality?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>a) queen – b) female – c) male – d) eggs – e) pupae – f) winged ants – g) larvae</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>Which book, journal, movie, or television series has given you information about ants?**</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Attitude</th>
<th>7</th>
<th>In my opinion, ants are*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>a) disgusting – b) exciting – c) fascinating – d) needless – e) boring – f) frightening</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>Ants and other insects are vermin, and I could do without them.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>a) fully agree – b) undecided – c) do not agree</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td>If there is an insect inside my room, I*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>a) kill it – b) call someone to remove it – c) leave it where it is – d) put it out by myself – f) examine it closely</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>I do not mind if a nonpoisonous ant runs on my hand.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>a) do not agree – b) undecided – c) fully agree</td>
</tr>
<tr>
<td>11</td>
<td></td>
<td>If I go to the zoo, I visit the insects inside the terrarium.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>a) never – b) rarely – c) undecided – d) often – e) always</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td>I keep an insect as a pet.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>a) no – b) undecided – c) yes</td>
</tr>
</tbody>
</table>

| Learning Enjoyment | 14 | Hands-on work with living ants |
|                   |   | a) was no fun – b) undecided – c) was fun |
|                   | 15 | Observing living ants inside their nests was* |
|                   |   | a) disgusting – b) boring – c) amazing – d) exciting |
|                   | 16 | I would like to continue working with ants in class. |
|                   |   | a) do not agree – b) undecided – c) fully agree |
|                   | 17 | I would like to observe living insects in class using stereo microscopes more often. |
|                   |   | a) do not agree – b) undecided – c) fully agree |

○ Results
The majority of students (85.6%) had not yet worked with living ants in school. Almost three-fourths (72.5%) were unable to describe any insects they had observed in class, while 14.2% named concrete insect species. Some students described other animals (7.2%) or insects and other animals (6.1%). In their leisure time, students had encountered ants in many different places. However, 8.1% of students claimed they had not seen ants in any place. Almost three-fourths (73.9%) of students had already seen
of different ant species. Of the different members of an ant colony, many students had encountered winged ants (65.4%) and the queen (42.7%), while only a few had seen larvae (24.6%) and pupae (11.5%). More than half of the students (57.1%) had come across ants in the media. Boys had more experience with ants than girls (Table 4). In experience scores, no significant differences between students of different class levels ($F = 0.90$, df = 2 and 456, $P = 0.408$) were found.

In the pretest, most students did not show anxiety toward ants (see Table 3: item 7, “frightening” chosen by 7.0%; item 10, “fully agree” selected by 66.7%). However, many students did not care about them (item 9, “kill it” chosen by 26.8%; item 8, “fully agree” and “undecided” together selected by 41.2%). The majority of students indicated that they would like to observe living ants in school: while half of all students (50.8%) absolutely agreed, 37.0% were willing to observe ants under the precondition that they are enclosed within a box. Another 4.8% objected to work with living ants, and 7.4% were undecided or did not give an answer. We found lowest attitude scores for intermediate secondary school in both tests (Figure 3). While no significant changes in attitudes after teaching units were observed for students of lower and higher secondary school, students of intermediate level had increased attitude scores in the posttest (Figure 3). Male participants had more positive attitudes than females in both tests (Table 4). Learning enjoyment was equal for all class levels ($F = 0.52$, df = 2 and 456, $P = 0.598$) and similar for boys and girls (Table 4). Students who had taken care of ants (module 4) scored higher in attitudes toward ants in the posttest ($M = 12.25$, SD = 4.09) than students who had not looked after ants themselves ($M = 11.36$, SD = 3.80; $t_{457} = 2.43$, $P = 0.016$). Learning enjoyment did not depend on particular teaching modules. We observed significant differences in posttest attitudes and learning enjoyment between students who had worked with ants for different periods of time: students who had kept ant colonies in class for 4 weeks achieved the highest scores, while students who had worked with ants for 2 weeks had the lowest scores (Figure 4).

Figure 5 shows that most students enjoyed teaching units with acorn ants. One-fifth (21.8%) of students achieved the maximum score of 10. The majority of students (73.9%) considered investigations with ants fun, while 9.8% disliked them. About half of the students (50.8%) would like to continue working with ants in class, while 23.7% were undecided, and 25.5% did not agree. A subsample of students ($n = 51$) had collected ants in the forest. The majority of these ($n = 41$) considered collecting ants as fun.

We found that many questions arose during teaching units. Fields of interest especially concerned ants’ abilities and senses (e.g., “How much weight can they carry? How do they communicate, smell, hear,

Table 4. Descriptive statistics, item-total correlations ($r_{it}$), and internal consistencies for constructs, classified by gender.

<table>
<thead>
<tr>
<th>Construct$^a$</th>
<th>Mean (SD)</th>
<th>Mean (SD)</th>
<th>Mean (SD)</th>
<th>$t$ (df)</th>
<th>$P$</th>
<th>$r_{it}$</th>
<th>Cronbach’s $\alpha$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experience$^+$</td>
<td>9.21 (3.49)</td>
<td>10.19 (6.90)</td>
<td>8.62 (3.13)</td>
<td>$-3.15$ (320)</td>
<td>0.002$^*$</td>
<td>0.64–0.70</td>
<td>0.67</td>
</tr>
<tr>
<td>Attitudes (pre)$^{++}$</td>
<td>11.62 (3.93)</td>
<td>12.98 (3.47)</td>
<td>10.25 (3.90)</td>
<td>$-7.92$ (450)</td>
<td>0.000$^*$</td>
<td>0.72–0.75</td>
<td>0.75</td>
</tr>
<tr>
<td>Attitudes (post)$^{++}$</td>
<td>11.83 (3.97)</td>
<td>12.62 (3.78)</td>
<td>11.00 (4.00)</td>
<td>$-4.46$ (457)</td>
<td>0.000$^*$</td>
<td>0.69–0.73</td>
<td>0.73</td>
</tr>
<tr>
<td>Learning Enjoyment$^{+++}$</td>
<td>7.20 (2.61)</td>
<td>7.21 (2.64)</td>
<td>7.20 (2.58)</td>
<td>1.48 (449)</td>
<td>0.141</td>
<td>0.67–0.75</td>
<td>0.75</td>
</tr>
</tbody>
</table>

$^a$ $E_{\text{max}} = 20$, $A_{\text{max}} = 21$, $LE_{\text{max}} = 10$. 

Figure 3. Comparison of pretest and posttest attitude scores classified by class level (possible range: 0–21).

Figure 4. Posttest attitude (possible range: 0–21) and learning enjoyment (possible range: 0–10) scores classified by time period of participation.
or see?; n = 45), reproduction and development (e.g., “How many eggs do they lay within one year? How do eggs hatch? Can we simulate a mating flight?; n = 33), combat behavior (e.g., “What will happen if two ants of different colonies meet? How do they behave when they are attacked?; n = 26), and nutrition (e.g., “How, how much, and when do ants eat in their natural habitat? Which food do they prefer?; n = 24).

Discussion

Students in this survey had come across ants in many different places in their leisure time (direct experience) and the media (symbolic experience). But given that ants are common throughout the world and colonize almost every habitat, it is astonishing that 37 students had not yet seen ants in reality in any place. Many students indicated that they had encountered winged ants (i.e., males) and queens. This is notable because male ants are only temporary members of colonies in summer, and queens are rarely seen compared with female worker ants, which are the most common caste. By contrast, students had least experience with developmental stages. These findings indicate that most students had met individual ants but had not yet had direct experience with whole colonies. The ants that students encounter most often are just one part of the whole superorganism, which is rarely visible without guidance. But it is their social behavior that makes ants particularly interesting; the questions students asked were mostly not related to individuals but to the whole colony. To motivate students to have a closer look at little insect societies, they need to be given opportunities for direct experience with ant colonies in the forest as well as indirect experience in school. The majority of students who collected ants in this study enjoyed the excursion. After this direct experience in the ants’ natural habitat, indirect experience in class is important because it enables students to see the small-sized ants clearly using stereo microscopes, and each student can take care of his or her own colony. Furthermore, students can conduct hands-on work with ants for many weeks within the framework of their regular science classes, while it is not possible to visit natural habitats in every lesson. Although ants are the only social insects among the hymenopterans that can be collected in the forest and then kept and used for investigations in class, they have rarely been integrated into science lessons so far.

We found that experience and learning enjoyment were similar for all class levels, such that acorn ants are equally useful for all age groups in secondary school. Although some students had inhibitions about carrying out investigations with the little insects (see also Sammet et al., 2015a), students in the pretest clearly stated that they wanted to do hands-on work with ants. Research kits take these inhibitions into consideration and allow students to keep ants in enclosed boxes. In the posttest, the majority of students had a high learning enjoyment score. This is in line with the findings of the interviews (Figure 6). After ant research, many students were interested to find out more: alongside questions for information, they mainly asked investigable questions (Harlen, 2006). Research with Temnothorax enables students to answer some of their own questions by investigation, which is satisfying and motivating (Harlen, 2006). Although students enjoyed ant research, no changes toward more positive attitudes were observed for lower and higher secondary school students. However, students at intermediate level, who had scored worst in the pretest, showed slightly higher posttest attitudes compared with the pretest. This is especially important given that positive attitudes toward, and interest in, school science decline as students grow older (Osborne & Collins, 2001). Hands-on work such as ant research may help prevent students from developing negative attitudes toward science.

Boys had more experience and higher attitude scores than girls. Previous research also suggested that girls’ attitudes toward
“I think it’s interesting and great that you and our teacher allow us to assume so much responsibility”

—female, lower level

“In my opinion, it would be better to do more hands-on work, and, I think, these insects are interesting. I wish we would do something like this more often.”

—female, intermediate level

“It was exciting. In the beginning, I thought it would be dull to observe the ants which don’t do anything but crawling around, but having a closer look using microscopes and so on was interesting.”

—female, upper level

“I think it was an exciting thing to observe the ants since actually they are so small, and usually you don’t really pay attention to them in nature.”

—female, lower level

“We saw them so clearly, and they were so big. Wow, these huge ants; inside the box they look so small.”

—male, lower level

**Figure 6.** Student quotes (translated from German) about hands-on work with acorn ants in their classrooms.

Science are less positive than boys’ (Osborne et al., 2003). However, boys and girls both enjoyed the ant research, which can, therefore, be integrated into science classes independently of gender-related attitudes. Learning enjoyment also did not rely on particular teaching units. However, we suggest that module 4 be mandatory, because research has shown that caring for an animal is of great importance for the development of evaluation skills and an integral part of the relationship to animals (Rost & Hartmann, 1994).

In conclusion, we found that students enjoyed ant research independently of class level, gender, and teaching units. The time period of research had an influence on learning enjoyment as well as on attitudes, and taking care of ants positively influenced attitudes. A second study will determine variables for effective learning achievement during ant research in class. Because only a subsample of students in our study were able to collect ants themselves, future research needs to examine whether this outdoor education, which gives students independence and responsibility (Rennie, 2010), influences students’ behavior toward a more positive environmental attitude (Bogner, 1998). The combination of direct and indirect experience may be even more associated with environmental attitudes and an emotional bond with these little insects.

To combine direct and indirect experience, students should be instructed to collect ants themselves. Thereby, classroom work is combined with natural encounters.

Students should take care of ants themselves to develop an emotional bond with these little insects.

Students have already encountered insects, but developmental stages are foreign to them. Acorn ants offer the opportunity to observe all developmental stages closely in a compact space.

Ants are supposed to be kept in class for several weeks, to improve attitudes and enable students to observe all developmental stages occurring at different seasons. Nevertheless, a change of topic might have a positive effect on learning enjoyment.

Teaching units should allow students space to find answers to their (investigable) questions by performing experiments themselves.

The diverse research possibilities facilitate learner-centered biology classes.

### Acknowledgments

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### References


### Considerations for Teachers in Using Acorn Ants

- Ant research is suitable for all secondary-school class levels as a progressive curriculum. Especially in the intermediate secondary level, ants can be integrated into science classes to improve attitudes toward insects.

- Boys and girls differ in experience and attitudes. These differences, as well as potential inhibitions about working with living insects, need to be taken into consideration.

- To combine direct and indirect experience, students should be instructed to collect ants themselves. Thereby, classroom work is combined with natural encounters.

- Students should take care of ants themselves to develop an emotional bond with these little insects.

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