for helping in the identification of the species of this fungus.

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ASPECTS OF HOST PREFERENCE IN TWO SPECIES OF APHIDS AND A JASSID (HOMOPTERA: INSECTA) INFESTING FERNS

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THE inability of phytophagous insects to efficiently utilize ferns and consequent paucity of insects feeding on ferns was first noticed by Schneider[1] and Brues[2]. Though such resistant factors in ferns like texture[3], aminoacid deficiency[4], poor nutritional composition[5], toxins[6,7], cyanogen[8], presence of thiaminase[9], exogenous ecdysone[10,11], and 'water soluble factors'[3] have been implicated, no adequate explanation is yet available to prove the influence of those factors on host resistance. However two aphid species, *Micromyzodium filicum* David and *Micromyzus nigrum* van der Goot and the jassid *Kolla tigrina* Distant appear to efficiently utilize and the fern host for their growth and development. In view of this anomaly, the present investigation was undertaken to study the variations in the chemical composition of eleven species of ferns, both infested as well as uninfested, to assess some of the biochemical parameters involving the degree of host preference in these insects.

The aphid species *Micromyzodium filicum* and *Micromyzus nigrum* are known to infest the ferns, *Pteris quadriaurita* Tetz, *Pteris quadriaurita* var *argyrarea*, *Blechnum braziliensis* and *B. orientale*. A comparatively meagre infestation of *Micromyzodium filicum* was also noticed in *Pityrograme chrysophylla* (Golden fern) and *Pityrograme pullchella* (Silver fern). An overall analysis of the population of these species on *P. quadriaurita*, *B. orientale* and *B. braziliensis* revealed that the species of *Blechnum* are preferred by these aphid species and their infestation on fern hosts is evident only at altitudes above 1,900 meters. The jassid *Kolla tigrina* does not exhibit any aggregation on the host plant, and no external morphological damage on the infested frond was evident. Consistent collections from areas in Anamalais and Nilgiris revealed the occurrence of this species in association with ferns only above 1,900 m.

Biochemical analyses of eleven species of ferns (table 1) revealed that the range of lipid concentration for insect attack is between 8–12 mg/g. In *Blechnum* species, though the concentration of total phenols appeared to be very high, the aphids tend to exploit the hosts for their nutritional requirement. Such a comparatively higher concentration of phenols may generally act as a repellent because of their high toxic nature. Adaptive specialization of aphids enables them to pierce and feed on the nutritious contents of phloem. But in the case of *Pteris quadriaurita*, a comparatively low concentration of phenols (2.2 to 9.5 mg/g) was noticed, alongside with an equally low amount of carbohydrates as compared to the rest of the ferns. A comparative assessment of the protein content in the ferns revealed that protein concentration is very high (6.25 to 7.00 mg/g) only in the case of *Pteris* species. A comparison of the nitrogen content of the different fern hosts revelaed that aphids prefer to feed on a high concentration of nitrogen for better survival and growth[12]. It is clear that the maximum utilization of fern hosts by aphids occurs only when the nitrogen content ranged from 0.04 to 1.12 mg/g. Any deviation from this range resulted in the absence of aphids. Though *Lomaria gibba*, *Diplazium lasiopteris* Kunze, *Cyrtomium falcatum* Pappe (var *caryotideum*), and *Gleichenia* sp have almost an equal concentration of carbohydrates as compared with that of *Blechnum* species, no infestation of aphids was evident on these hosts. Though *Tectoria macrodonta* showed an equal concentration of phenol as that of *Blechnum* species, the former host was not preferred. Hence, it appears that the low concentration of carbohydrate alongside with the low concentration of phenols (as in *P. quadriaurita* var *argyrarea*) or a low concentration of carbohydrate and a high concentration of phenols (as in *Blechnum* species) appears to act as attractants towards aphids infesting ferns. Nitrogen concentration for aphid infestation appears to range from 0.42 to 1.42% and concentrations below and above this level tend to act as deterrents for insect attack. This is supported by the fact that fern hosts like *Polypodium*

Table 1 *Biochemical analyses of some fern species*

Fern species	Lipid mg/g	Carbohydrate mg/g	Phenol mg/g	Protein mg/g	Nitrogen %	CHO/Pro ratio	CHO/N_2 ratio
Pteris quadriaurita	8	240	2.2	6.25	1.00	38.4	240.0
Pteris quadriaurita argyrarea	3	210	9.5	7.00	1.12	30.0	187.5
Blechnum orientale	8	750	62.0	3.10	0.50	241.9	1500.0
Blechnum braziliensis	16	720	68.0	2.50	0.40	288.0	1800.0
Polypodium phegopteris (with sori)	12	600	54.0	43.00	7.00	13.9	85.7
P. phegopteris (without sori)	8	580	56.0	1.70	0.28	341.1	2071.4
P. phegopteris (infested)	12	560	43.0	1.20	2.20	466.7	254.5
Lomaria gibba	12	725	35.0	1.70	0.28	426.5	2589.3
Diplazium lasiopteris	4	700	36.5	3.10	0.50	225.8	1400.0
Mycrolepia sp.	36	660	12.5	2.50	0.40	264.0	1650.0
Tectoria macrodonta	20	220	69.0	3.10	0.50	70.9	440.0
Cyrtomium falcatum	4	710	4.5	1.30	0.21	546.2	3380.9
Gleichenia sp.	4	710	32.5	3.75	0.60	202.9	1183.3

CHO—carbohydrate; Pro—protein; N_2—nitrogen

phegopteris which have a higher concentration of nitrogen (2.2 to 7.0 mg/g) tend to repel aphids, which therefore do not prefer to feed on this host. It was also observed that *Diplazium lasiopteris*, *Mycrolepia* sp, *Tectoria macrodonta* and *Gleichenia* sp have an almost equal amount of nitrogen as found in *Blechnum* species, but no infestation was noticed on the above mentioned host plants. This may be due to the very high concentration of carbohydrates in those fern hosts.

That carbohydrates and nitrogen do play a synergetic role in enabling these compounds to act either as attractants or repellants for jassid species has been observed by Jayaraj[13]. But the infestation of *Kolla tigrina* on *Pteris* species reveals that the concentration of phenols and proteins of the host plant together do play an important additional role in the determination of host preference. Biochemical analyses revealed that the fern species *P. quadriaurita* and *P. quadriaurita* var *argyrarea* have comparatively lower concentration of carbohydrates (240 mg/g and 210 mg/g respectively) and phenols (2.2 mg/g and 9.5 mg/g), and a higher concentration of protein and nitrogen when compared to the other fern species analyzed. But this higher concentration of nitrogen and protein is lower than that found in dicot plants. While a low concentration of both carbohydrate and nitrogen attracts *Kolla tigrina* towards their fern hosts, a low concentration of nitrogen with a higher carbohydrate content appears to act as a repellent. Though jassids are not attracted to fern hosts with lower protein content, ferns with high protein content also do not attract jassids, if there is a high phenol concentration in them. Hence, the concentration of such chemical compounds as, carbohydrates, lipids, nitrogen, phenols, and proteins either individually or synergetically appears to decide their role either as attractants or as repellents.

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STUDIES ON THE CROSS-INFECTIVITY OF NUCLEAR POLYHEDROSIS VIRUS OF *ADISURA ATKINSONI* MOORE (NOCTUIDAE: LEPIDOPTERA)

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GENERALLY insect viruses are considered to be relatively species-specific or at least have a limited host range[1]. However, cross-infection of insect viruses between closely related as well as unrelated lepidoptera have increased recently[2,3]. Though, an occurrence of a nuclear polyhedrosis virus (NPV) in *Adisura atkinsoni*[4], a major pod borer on field beans, *Lab-lab purpureus* (Linn) Sweet and its field efficacy[5] has been reported, mass production of NPV for further field study is limited since it undergoes a pupal diapause[6]. Hence, a study was conducted to find out the cross-infectivity of NPV of *A. atkinsoni* to four insects *viz*, (i) tobacco leaf caterpillar, *Spodoptera litura* Fabricius (Noctuidae), (ii) gram caterpillar, *Heliothis armigera* Hübner (Noctuidae) which were reared on artificial diet[7] (iii) jute caterpillar, *Spilosoma obliqua* Walker (Noctuidae) and (iv) plume moth, *Sphaenarches anisodactylus* Walker (Pterophoridae) which were also reared on artificial diet[6,9]. These insects are chosen because although they belong to different species and genus, they are found mostly on the same host crop *viz*., field beans. Therefore, if the cross infectivity NPV of *A. atkinsoni* proves positive to any of the alternate hosts the same host can be used both for mass production of virus as well as for the control of both the pests occurring simultaneously on the field beans. One to seven-day-old larvae of varying number, in each of the four species were surface contaminated with 0.1 ml of NPV of *A. atkinsoni*, containing 1×10^6 polyhedral inclusion bodies (PIB) per container. The cause of the death was diagnosed microscopically and positive cross-infection was considered following the criteria suggested by Tanada and Chang[10], *viz*, (i) the reciprocal transmission of two viruses to the two insects, (ii) the infectivity of the virus to the host after the passage through the alternate host (iii) the symptom and pathology on the two hosts, which are essential characteristic for each host species, regardless of whether the virus had been obtained from the original or alternate host and (iv) that the activation of a latent infection was unlikely as shown by the test-feeding the larvae with normal midgut and a third virus, the cytoplasmic virus of the silkworm.

The study revealed that NPV of *A. atkinsoni* was not cross-infective to other test insects except to that of *H. armigera*, although high dose of inoculum was used. There was no death with typical symptoms and they have completed their larval and pupal development and emerged as normal adults. Similarly no mortality was observed in the control. But, in the case of *H. armigera*, all the different stages of the larvae were found dead, showing typical symptoms of NPV infection, within 4–9 days after inoculation period depending upon the stage of the insect tested. Since NPV of *A. atkinsoni* was cross-infective to *H. armigera*, a study was also conducted to determine its infectivity to the original host *viz. A. atkinsoni*, after passing it through alternate host *viz. H. armigera*. Further, a cross-infectivity test was also carried out with NPV isolated from *H. armigera* against *A. atkinsoni*. The test was conducted according to the method described above using 0.1 ml of respective NPVs, containing 1×10^6 PIB container.

The results revealed (table 1) that NPV of *H. armigera* was cross-infective to *A. atkinsoni* and only 40 to 50 % mortality was recorded over an incubation period ranging from 5 to 11 days although a high dose of virus was used. Most of them died of bacterial and other unknown causes whereas the NPV of *A. atkinsoni* after passing through its alternate host *viz*, *H. armigera*, was found to be highly effective causing 100 %

Table 1 *Effect of heterologous virus on A. atkinsoni* and *H. armigera*

Name of the Test insect	Inoculum virus	Incubation period (range in days)	% mortality (range)
A. atkinsoni	*H. armigera* NPV	5–11	40–50
H. armigera	*A. atkinsoni* NPV	4–9	100