The taxonomic study of encyrtid parasitoids (Hymenoptera: Chalcidoidea) of diaspids from India

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Abstract
The Diaspidids (Hymenoptera: Diasapididae) attack a variety of plants and fruit trees like mango, apple, peach, citrus and plants like rose, tea etc. by a constant sucking of plant juices. Their mode of feeding not only damages the plant but also causes secondary infections. The biological control of these diaspids can be done by many Indian encyrtid parasitoids, the successful biological control programmes largely depend upon the correct identification of these parasitoid species, as well as their correct status (primary or secondary parasitoids). The sound taxonomic and biological knowledge regarding these parasitoids is needed before their recommendation in any biological control programme. In the present paper, a basic taxonomic study has been conducted to provide valuable information on Indian encyrtid parasitoids through keys, description, their host and distribution.

Keywords: Taxonomy; Parasitoids; Diaspidids.

Introduction
Armoured scales/Diaspidids are the smallest of scale insects (Fig. 1), ranging in size from 1 – 3mm and member of the homopterous family Diaspididae (Superfamily Coccoidea). The scale insects characterized by the presence of a protective shell that provide protection during the life of the insects. The armoured scale contain species that attack a variety of plants and fruits tree like mango, apple, peach, citrus and other plants like rose, tea, etc. by permanent attachment on plant stem and leaves, constantly suck plant juices with the help of their sucking mouth parts which lead to damage of the plant and also causes secondary infections (DeBach, 1964). Majority of Homoptera in the families Coccoidea, Diaspididae and Pseudococcidae are parasitized by encyrtid species and their parasitoid are found in all habitats and are extremely important as biological control agents. Noyes (1990b) summarized the biology and taxonomy of encyrtid genera known to attack armoured scales.

The author has chosen the armoured scales due to the heavy loss and damage to fruit trees in our country caused by them with an emphasis on their biological control by many encyrtid parasitoids. It is true that success of any biological control programme depends largely on the correct identified both at generic and specific levels of the parasitoid species, its host and recognition whether a primary parasitoid or secondary parasitoid therefore taxonomic studies are needed before the recommendation of parasitoid in biocontrol of pest species. So far, there is no comprehensive work dealing with the encyrtid parasitoids from India to control the population of pest species so that the food production of our country will enhance. The present study was conducted to facilitate available information on the encyrtid parasitoids by means of keys and a list (Table 1) including encyrtid parasitoids, number of species in world and in India, their diaspid host (armoured scale insects) and their distribution (Table 2).

Family Encyrtidae Walker
The family Encyrtidae constitutes an important group of parasitic hymenopteran insects which are essential in maintaining the pest population under check and therefore extensively used in the Biological Control Programmes. The present work includes 14 encyrtid genera namely:

1. Genus Adelencyrtus Ashmead
2. Genus Arrhenophagus Auriuillius
3. Genus Caenohomalopoda Tachikawa
4. Genus Cerapteroceroides Ashmead
5. Genus Coccidencyrtus Ashmead
6. Genus Comperiella Howard
7. Genus Epitetracnem Girault
8. Genus Metaphycus Mercet
9. Genus Plagiomerus Crawford
10. Genus Teleterabratus Compere & Zinna
11. Genus Thomsonica Ghesquiere
12. Genus Trichomasthus Thomson
13. Genus Xenostyrix Girault
14. Genus Zaomma Ashmead
Distinguishing Characters

Female: (Fig. 2) Size small to moderately large, 0.50 – 2.00 mm. Antenna 11-segmented (Fig. 3). Easily recognized by transverse and triangular axillae that meet medially and the position of cerci anterior to the tip of the abdomen; presence of very short marginal vein (Fig. 4). mesoscutum with complete or incomplete notaular lines, mesopleuron convexly enlarged.

Male: Sexual dimorphism in body color and antennal structure (Fig. 5) but other characters are similar to those in females except for the external genitalia.

1. Genus Adelencyrtus Ashmead [Key couplet: 6]
   Adelencyrtus Ashmead, 1900b: 401. Type species.  
   Encyrtus chionaspidis Howard, by original designation

   Epiencyrtoides Girault, 1915a: 108. Type species  
   Epiencyrtoides quadridentatus Girault, by original designation. As synonym of Adelencyrtus by Mercet, 1921: 698.

Diagnosis
Body excluding antennae, wings, legs, tegula completely dark; head dorsum nearly flat, in side view, head triangular and strongly inflexed at top of scrobes; mesoscutum with dark setae; mandibles 4-dentate; clava apically rounded or transversely truncate; fore wing infuscation relatively weak and at most with only two hyaline spots distal of venation; hypopygium not reaching more than two-third length along gaster.

Species and distribution
World, 25 species, cosmopolitan; 10 species from India.

2. Genus Arrhenophagous Aurivillius [Key couplet: 4]
   Arrhenophagous Aurivillius, 1888: 144. Type species  
   Arrhenophagous chionaspidis Aurivillius, by monotypy.

   Mymariella Risbec, 1951: 402. Type species  

Diagnosis
Mandibles with one pointed tooth; antenna with 2-4 anelliform segments, ad pressed with clava, clava large at least as long as remainder of antenna; fore wing broad, with distal veins not clearly defined; tarsi 4-segmented.

Species and distribution
Only 2 species; 1 species from India.

3. Genus Caenohomalopoda Tachikawa [Key couplet: 5]
   Caenohomalopoda Tachikawa, 1979a; 169. Type species Pseudohomalopoda shikokuensis Tachikawa, by original designation.

Diagnosis
Funicle with 4-segmented, usually quadrate to broader than long; fore wing infuscate with well-defined rays or bands; hypopygium not reaching to the apex of gaster; tarsi 5-segmented.

Species and distribution
World, 7 species; 3 species from India.

4. Genus Cerapteroceroides Ashmead [Key couplet: 7]
   Cerapteroceroides Ashmead, 1904b: 156. Type species  
   Cerapteroceroides japonicas Ashmead, by monotypy.

   Metacerapteroceroides Ishii, 1928: 151. Type species  
   Ceraperoceroides fortunatus Ishii, by original designation. Synonyms by Tachikawa, 1963: 142.

Diagnosis
Flagellum broadened and flattened, scape triangular or trapezoid, pedicel large distinctly broader than F1; fore wing infuscate with deeper curve, broad with marginal vein subequal to stigmatic vein.

Species and distribution
Old World, 8 species; 5 species from India.

5. Genus Coccidencyrtus Ashmead [Key couplet: 9]
   Coccidencyrtus Ashmead, 1900b: 383. Type species  
   Encyrtus ensifer Howard, by monotypy and original designation.

   Encyrtomyia Girault, 1915a: 131. Type species  

Diagnosis
Mandibles with one or two teeth and a truncation; first segment of funicle no longer than broad, fore wing hyaline, marginal vein more than twice as long as broad; mesopleuron enlarged posteriorly, hypopygium not reaching apex of the gaster.

Species and distribution
World, 7 species; 3 species from India.
Species and distribution
World, about 30 species, cosmopolitan; 3 species from India.

6. Genus Comperiella Howard [Key couplet: 7]
Comperiella Haward, 1906: 121. Type species Comperiella bifasciata Howard, by monotypy.
Pseudanusia Girault, 1915a: 155. Type species Pseudanusia pia Girault, by monotypy and original designation. Synonymy by Girault, 1917b: 37.

Diagnosis
Flagellum broadened and flattened, rarely F1 not transverse, antennal scape not more than 3x as long as broad, stigma vein with sensilla not arranged in a square, uncus present; fore wing with one or two longitudinal infuscate rays; scutellum without a distinct bundle or tuft of setae or scale like setae.

Species and distribution
World, 9 species; 5 species from India.

7. Genus Epitetracnemus Girault [Key couplet: 6]
Epitetracnemus Girault, 1915a: 164. Type species Epitetracnemus sexguttatipennis Girault, by monotypy and original designation.

Diagnosis
Body completely dark; clava apically rounded or transversely truncate; fore wing strongly infuscate from below parastigmatic to apex and enclosing at least three hyaline spots distal of venation; hypopygium reaching apex of gaster.

Species and distribution
World, 6 species; 1 species from India, and Indet. species from India.

8. Genus Metaphycus Mercet [Key couplet: 13]

Diagnosis
Antenna except sometime scape, cylindrical, neither flattened or broadened, funicle with at least 6 segments; thorax at least partly yellow or orange, mesoscutum with notalar lines present at least in anterior, scutellum without an apical flange.

Species and distribution
World, more than 400 species, cosmopolitan; 15 species from India.

9. Genus Plagiomerus Crawford [Key couplet: 2]
Plagiomerus Crawford, 1910: 89. Type species Plagiomerus diaspidis Crawford, by monotypy and original designation.

Diagnosis
Mandibles with a truncate to serrate apex; funicle with 4 segments all at least slightly longer then broad; scutellum usually with two large scale like setae; hypopygium reaching to the apex of gaster; tarsi 5 segmented.

Species and distribution
World, 7 species; 2 species from India.


Diagnosis
Clava with apex rounded and dorsal surface not curved, not all funicle segments longer than broad, at least one segment quadrates to broader than long; fore wing hyaline or infuscation faint and diffuse, or very pale brown; thoracic dorsum completely dark and metallic; hypopygium not extending to apex of gaster.

Species and distribution
World, 4 species, Australasian and Oriental; 1 species from India.

11. Genus Thomsonisca Ghesquier [Key couplet: 13]
Thomonisca Ghesquiere, 1946: 369. [Replacement name for Thomsoniella Mercet]


Diagnosis
Mandibles with one or two teeth and a truncation; clava with apex rounded; fore wing with postmarginal vein not longer than stigma vein; mesoscutum and scutellum completely dark; hypopygium not reaching more than from fifth length along gaster.

Species and distribution
World, 6 species; 4 species from India.

12. Genus Trichomasthus Thomson [Key couplet: 10]

Diagnosis
Head and thorax with conspicuous pale setae, mandibles with one or two teeth and a truncation; all funicle segments longer than broad; fore wing hyaline; mesopleuron enlarged posteriorly, touching base of gaster.

Species and distribution
World, 31 species, cosmopolitan; 3 species from India.

13. Genus Xenostryxis Girault [Key couplet: 12]
Xenostryxis Girault, 1920a: 41. Type species Xenostryxis margiscutellum Girault, by monotypy.

Diagnosis
Mandibles tridentate; all funicle segments longer than broad, flagellum neither broadened nor flattened, more or less cylindrical; fore wing hyaline, marginal vein clearly longer than broad; dorsum of thorax yellow or orange.

Species and distribution
Old World, 8 species; 2 species from India.

14. Genus Zaomma Ashmead [Key couplet: 9]
Zaomma Ashmead, 1900b: 401. Type species Encyrtus argentipes Howard, by monotypy and original designation.

Diagnosis
Funicle with at least 6 segments; fore wing hyaline, marginal vein longer than stigmal vein; scutellum with a group of course, long, dark setae arranged in a more or less compact bundles or tuft.

Species and distribution
Only 1 species from India.

Illustrated key to encyrtid genera, parasitoids of armoured scale insects/Diaspidids
1. Fore wing hyaline (Fig. A) .................................................................................................................. 2
   - Fore wing infuscate (Fig. a) ............................................................................................................. 3

2. Tarsi 4 segmented
   - Tarsi 5 segmented, funicle segment except F1, quadrate to broader than long (Fig. A), marginal
     vein at least as long as stigma vein (Fig. B), scutellum usually with large scale like setae (Fig. C)
     \textit{Plagiomerus} Crawford

3. Fore wing with well-defined infuscate rays or bands (Fig. A)
   - Fore wing with well-defined hyaline spots (Fig. a)
4. Mandible with one pointed tooth (Fig. A), antenna with 2-4 anelliform segments (Fig. B), clava large, fore wing broad

\[ \text{Arrhenophagus Aurivillius} \]

- Mandible with one or two teeth and a truncation or with 3 teeth (Fig. a) 

\[ \text{Caenohomalopoda Tachikawa} \]

5. Four funicle segments (Fig. A), hypopygium not reaching apex of gaster

\[ \text{Caenohomalopoda Tachikawa} \]

- Six funicle segments (Fig. a)
6. Fore wing with at least 3 hyaline spots distad of venation (Fig. A), head with strong transverse line of dense silvery white setae below and across face. 

..............................................................*Epitetracnemus* Girault

- Fore wing with only two hyaline spots distad of venation (Fig. a) transverse line of setae across face absent or very sparse. 

..............................................................*Adelencyrtus* Ashmead

7. Fore wing with one or two longitudinal infuscate rays (Fig. A) 

..............................................................*Comperiella* Howard

- Fore wing with many infuscate rays radiating from a longitudinal line in centre of wing, scape triangular, pedicel broader than F1 (Fig. a) 

..............................................................*Cerapteroceroides* Ashmead
8. Mandible tridentate (Fig. A) ................................................................. 10
   - Mandible with one or two teeth and a truncation (Fig. a) ......................... 9

9. Marginal vein more than twice as long as broad (Fig. A), occipital margin more or less rounded
   ........................................................................................................ Coccidencyrtus Ashmead
   - Marginal vein at most 2x as long as broad, stigma vein and parastigma not down curved (Fig. a),
     funicle segment short to transverse .................................................. Zaomma Ashmead
10. Fore wing infuscate (Fig. A), occipital margin rounded or sharp, head and thorax with conspicuous pale setae ……………………………………………………. Trichomasthus Thomson
   - Fore wing hyaline or very pale brown (Fig. a)……………………………………………………………………………………………………………………..11

11. Thoracic dorsum largely yellow or orange (Fig. A) ………………………………………………………………………………………………………12
   - Thoracic dorsum completely dark and metallic, hypopygium not reaching past apex of gaster, clava with apex rounded …………………… Teleterebrates Compere & Zinna
12. Marginal vein very short or punctiform (Fig. A) ......................................................... 13
- Marginal vein at least twice as long as broad, hypopygium not extending more than three quarters along gaster, at least one funicle segment quadrate to broad (Fig. a) ................
........................................................................................................................................ Xenostryxis Girault

13. Toruli situated relatively lower, their lower margin below lower eye margin (Fig. A), foe wing with linea calva interrupted or closed or dorsal surface of wing by at least one line of setae .................................................................................................................. Metaphycus Mercet
- Toruli situated relatively higher on head, with their lower margins level with or above lower eye margins (Fig. a) ................................................................. Thomsonisca Ghesquiere
Table 1. List of Encyrtid parasitoid genera including total number of species (World and Indian), diaspidid host and distribution.

<table>
<thead>
<tr>
<th>Parasitoid Genera</th>
<th>Total No. of Species</th>
<th>Diaspidid Host(s)</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>World</td>
<td>India (excluding those species with unknown hosts)</td>
<td></td>
</tr>
<tr>
<td>Adelencyrtus</td>
<td>25</td>
<td>-</td>
<td>Andaman &amp; Nicobar Island, Assam, Delhi, Karnataka, Orissa, Pondicherry, Uttaranchal, Uttar Pradesh, West Bengal.</td>
</tr>
<tr>
<td>Ashmead</td>
<td>-</td>
<td>Adelencyrtus moderatus (Howard)</td>
<td>Andhra Pradesh</td>
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<td></td>
<td></td>
<td>Adelencyrtus coxalis, Hayat, Alam &amp; Agarwal</td>
<td>Kerala</td>
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<td></td>
<td></td>
<td>Adelencyrtus axillaris (Girault)</td>
<td>Delhi, Gujarat, Karnataka, Tamil Nadu, Uttar Pradesh.</td>
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<tr>
<td></td>
<td></td>
<td>Adelencyrtus mayurai (Subba Rao)</td>
<td>Andaman &amp; Nicobar Islands, Jharkhand, Karnataka, Rajasthan, Uttar Pradesh.</td>
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<tr>
<td></td>
<td></td>
<td>Adelencyrtus bimaculatus Alam</td>
<td>Bihar, Delhi, Karnataka, Maharashtra</td>
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<td></td>
<td></td>
<td>Adelencyrtus bifasciatus (Ishii)</td>
<td></td>
</tr>
<tr>
<td>Arrhenophagus Aurivillus</td>
<td>2</td>
<td>1</td>
<td>Andhra Pradesh, Karnataka, Uttarakhand</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Arrhenophagus chionaspidis (Hayat); Diaspis sp.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Genus</th>
<th>Species Descriptions</th>
<th>Hosts</th>
<th>Regions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Caenohomalopoda</strong></td>
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<tr>
<td>Tachikawa</td>
<td><em>Caenohomalopoda longistylata</em> (Singh)</td>
<td>On Indet. diaspiddid</td>
<td>Mizoram</td>
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<td></td>
<td><em>Caenohomalopoda longiclavava</em> (Basha &amp; Hayat)</td>
<td></td>
<td>Bihar</td>
</tr>
<tr>
<td></td>
<td><em>Caenohomalopoda koreana</em> (Paik &amp; Paik)</td>
<td></td>
<td>Tamil Nadu</td>
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<tr>
<td><strong>Cerapteroceroides</strong></td>
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<tr>
<td>Ashmead</td>
<td><em>Cerapteroceroides ghorpadei</em> (Hayat)</td>
<td>Hyperparasitoids of diaspidae via other Encyrtidae and Aphelinidae</td>
<td>Karnataka, Kerala</td>
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<td></td>
<td><em>Cerapteroceroides similis</em> (Ishii)</td>
<td></td>
<td>Himachal Pradesh,</td>
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<td></td>
<td><em>Cerapteroceroides japonicus</em> (Ashmead)</td>
<td></td>
<td>Uttarakhand</td>
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<td></td>
<td><em>Cerapteroceroides angustifrons</em> (Singh &amp; Agarwal)</td>
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<td>Assam</td>
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<td></td>
<td><em>Cerapteroceroides latifrons</em> (Singh &amp; Agarwal)</td>
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<td>Assam</td>
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<tr>
<td><strong>Coccidencyrtus</strong></td>
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<tr>
<td>Ashmead</td>
<td><em>Coccidencyrtus mandibularis</em> (Hayat, Alam &amp; Agarwal)</td>
<td><em>Pinnaspis strachani</em> (Hayat); <em>Phenocaspis</em> sp. on <em>Mangifera indica</em> (Hayat et al.)</td>
<td>Karnataka, Uttar Pradesh</td>
</tr>
<tr>
<td></td>
<td><em>Coccidencyrtus shafeei</em> (Hayat, Alam &amp; Agarwal)</td>
<td><em>Aonidiella</em> sp. (Hayat et al.) on <em>Mangifera indica</em></td>
<td>Kerala, Rajasthan,</td>
</tr>
<tr>
<td></td>
<td><em>Coccidencyrtus clavatus</em> (Hayat, Alam &amp; Agarwal)</td>
<td><em>Lepidosaphes</em> sps. (Hayat et al.) on <em>Tamarindus indica</em></td>
<td>Uttar Pradesh</td>
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<td>Andaman &amp; Nicobar</td>
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<td>Islands, Andhra Pradesh</td>
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<tr>
<td><strong>Comperiella</strong></td>
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<tr>
<td>Howard</td>
<td><em>Comperiella indica</em></td>
<td><em>Aspidiotus tamarindi</em> (Ayyar) on tamarind</td>
<td>Tamil Nadu, Uttar Pradesh</td>
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</tbody>
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| Comperiella lemniscata Compere & Annecke | Aonidiella orientalis (Hayat) on Zizyphus jujube (Glover) same host on Eugenia jambolana (Agarwal) same on Psidium guajava (Hayat) same on Ficus sp. (Hayat) on Carissa grandiflora (Compere & Annecke) | Jharkhand, Maharashtra, Rajasthan, Uttar Pradesh |
| Comperiella bifasciata Howard | Aonidiella aurantii (Subba Rao) on rose; Aonidiella citrina (Flanders); Aspidiotus destructor on mango (Tandon & Shrivastava) | Delhi, Karnataka, Tamil Nadu, Uttar Pradesh |
| Comperiella aspidiotiphagha Subba Rao | Aonidiella orientalis on Eugenia (Hayat et al.); jambolana (Agarwal) same host on Dalbergia sissoo (Subba Rao); Psidium guajava and Ficus sp. (Hayat et al.) Aspidiotus spp. on Dalbergia sissoo | Delhi, Rajasthan, Uttar Pradesh |

| Epitetracnemus Girault | 6 | 1 |
| Epitetracnemus intersectus | On Indet. diaspсидid scales | Andaman & Nicobar Islands |

| Metaphycus Mercet | More than 400 sp. | 15 |
| Metaphycus zebratus (Mercet) | Aonidiella orientalis Dalbergia sissoo (Shafee et al.) | Himachal Pradesh, Punjab, Uttar Pradesh |
| Metaphycus mashhoodi Noyes & Woolley | Aonidiella orientalis on Eugenia jambolana (Alam) | Uttar Pradesh |

| Plagiomerus Crawford | 7 | 2 |
| Plagiomerus bangaloriensis Shafee, Alam & Agarwal | Aonidiella orientalis on Polygonum glabrum (Hayat) | Karnataka, Kerala |

<p>| Teleterebratus Compere &amp; Zinna | 4 | 1 |</p>
<table>
<thead>
<tr>
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<th>Species and Location</th>
</tr>
</thead>
<tbody>
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<td>Narayanan in Jammu &amp; Kashmir</td>
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<tr>
<td><strong>Quadriaspidiotus perniciosus</strong></td>
<td>Narayanan in Jammu &amp; Kashmir</td>
</tr>
<tr>
<td><strong>Aspidiotus destructor</strong></td>
<td>Subba Rao on <em>Mangifera indica</em>, <em>Aulacaspis sp.</em> (Subba Rao) on mango, <em>Phenocaspis sp.</em> (Subba Rao) on <em>Mangifera indica</em></td>
</tr>
<tr>
<td><strong>Aulacaspis sp.</strong></td>
<td>(Subba Rao); <em>Pseudaulacaspis barberi</em> (Subba Rao) on <em>Mangifera indica,</em> <em>Pseudaulacaspis cockerelli</em> (Hayat)</td>
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<td><strong>Thomsonisca indica</strong></td>
<td>Hayat on <em>Ficus sp.</em> (Hayat)</td>
</tr>
<tr>
<td><strong>Trichomasthus assamensis</strong></td>
<td>Hayat &amp; Basha in Assam, Kerala</td>
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<tr>
<td><strong>Xenostryxis tenuicauda</strong></td>
<td>Hayat in Kerala</td>
</tr>
<tr>
<td><strong>Zaomma lambinus</strong></td>
<td>Walker in Andaman &amp; Nicobar Island, Kerala, Uttar Pradesh</td>
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</tbody>
</table>
Table 2. Distribution of Encyrtid parasitoids in States of India.

<table>
<thead>
<tr>
<th>GENUS</th>
<th>SPECIES</th>
<th>STATE CODES</th>
<th>ABBREVIATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apcithynnus</td>
<td>moderatus</td>
<td>AN</td>
<td></td>
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<td>croceus</td>
<td>AP</td>
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<td>Apcithynnus</td>
<td>arillaris</td>
<td>AR</td>
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<tr>
<td>Apcithynnus</td>
<td>margravi</td>
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<td>bimaculatus</td>
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*Abbreviations (State Codes)*
- **AN**: Andaman & Nicobar Islands
- **AP**: Andhra Pradesh
- **AR**: Assam
- **BR**: Brihal Pradesh
- **CT**: Chandigarh
- **DD**: Cuddapah
- **DN**: Darjeeling and Nagaland
- **DL**: Delhi
- **GA**: Goa
- **GI**: Gujarat
- **HP**: Haryana
- **HR**: Himachal Pradesh
- **JK**: Jammu and Kashmir
- **JH**: Jharkhand
- **KA**: Karnataka
- **KL**: Kerala
- **LD**: Lakshadweep
- **MP**: Madhya Pradesh
- **MJ**: Maharashtra
- **ML**: Manipur
- **MN**: Mizoram
- **OR**: Odisha
- **PA**: Punjab
- **PB**: Puducherry
- **PT**: Rajasthan
- **SK**: Sikkim
- **TN**: Tamil Nadu
- **TR**: Tripura
- **UP**: Uttar Pradesh
- **WB**: West Bengal

Discussion
The present study revealed the importance of Encyrtid Parasitoids in controlling Armoured scale insects (extremely harmful and injurious to many important fruit trees and ornamental plants). The identification of these Parasitoids is essential by giving identifying keys, and a list providing many species of Parasitoids, host of Parasitoids and their distribution in India. The studied 14 Encyrtid Parasitoids otherwise act as efficient biocontrol agents against Armoured scale insects. It is well known that any success or failure in any biocontrol programme depends on the correct identification of the host and its Parasitoid, incorrect identification leads to waste of years of manpower and loss of money. So, correct identification is very important for any success.

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References


Fig. 1: Armoured scale insects (Family Diaspididae)

Fig. 2: Comperiella bifasciata (Family Encyrtidae)

Fig. 2: ♀ Antenna

Fig. 3: Forewing (marginal vein)

Fig. 4: ♂ Antenna