Entomology, the study of insects is highly fascinating biological science. Insects are the most abundant form of animal life on the earth. They are found nearly everywhere in the world except in the open seas and some parts of the polar regions. Whether they are considered helpful, harmful or neutral to man depends largely on whether man cooperating, competition or indifferent to their presence.

Insects\(^1\) are members of phylum Arthropoda having a well defined body structure. Insects may be helpful to man by producing directly or indirectly material of economic value, such as silk, honey beewax, shelliac, etc. by aiding in the production of fruits, vegetables, flowers, and seeds, through pollination activity, by acting as scavengers-attacking and destroying dead plants and animals, by destroying noxious plants, by their medicinal value particularly honey bee venom for treating arthritis.

Insect may be harmful\(^2\) to men and cause great economical loss by damaging or destroying agricultural crop and other valuable plants by aiding in the spread and development of bacteria, fungi, viruses that produce disease in plants.

Insects are highly injurious\(^3\) to human and animal health and comfort. Some insects notably mosquitoes and flies annoy men and other animals by their bites and stings. Others such as lice, have become adapted to more or less continuous life upon animals and cause much discomfort and less of vitality. Not only do they live externally on animals, but also internally in the skin tissue, and in a
few cases they live within the flesh and in the alimentary tract, besides direct loss due to their presence, insects transmit disease organisms from one person or animal to another. Some important insect born disease organisms are responsible for malaria, bubonic plague, typhoid, and yellow fever, cases of allergy (hay fever; asthma) are frequently caused by exposure of susceptible person to dried insect scales and hairs. Not only is the loss of life because of insect borne disease a serious, but the total loss of productive labour through illness is tremendous.

Insects destroy at least 5% of the world production of all cereal grains after they are harvested and while they are in storage on the form in elevators or warehouses.

It is difficult to make an accurate estimate of the monetary loss suffered from insects directly detrimental to man, but time lost form work, loss in business at resort and vacation areas. Cost of screening homes and buildings, lowered efficiency and medical expense, would amount to a considerable sum.

The damage caused by insects to agriculture crop and human health is enormous. This damage is particularly great in tropical countries like India and other Asian Countries, where the conditions of temperature and humidity are quite favourable for their growth. Though several methods are available for their control, the chemical method of using insecticides has been playing a vital role. Artificial
controls are applied by man. They are employed to reduce the population of insects.

The ultimate goal of any control programme is to shift on adverse “balance of nature” to favour man. These include physical control (use of electromagnetic energies light, and colour trap etc.): prophylactic control by creating physical and sensory barriers like repellents (oil of citronella, repels, mosquito, dimethyl phthalate, indolone), attractants (pheromones, methyl eugenol), antifeedants (like flavonoids, carbamates), cultural control is accomplished by farming practices like crop rotation; legislative control includes quarantine measures, rules for inspection and testing of seeds, seedling and insecticides; biological control measures are usually expensive and tedious like genetic control and introduction of parasites (ex, introduction of lady beetle from Australia to California to control scale in 1988-1989 to control citrus black fly in Cuba and Mexico). Mechanical control is useful in small forms. This includes hand picking of easily located and detectable pest and their destruction ex. egg batches of hairyly caterpillars. Destruction of infected parts of plants can also be done.

Chemical control involves the use of inorganic natural, and synthetic organic insecticides. Natural control of insects does not depend on man and it affects the distribution and welfare of insects. They depend on environmental conditions and also known as environmental resistance. These include climatic factors temperature
extremes, humidity, high winds etc., biotic factors (predators, parasites, natural resistance of plants) and topographical factors (oceans, deserts, mountain ranges, which act as natural barriers to their free migration).

The word insecticides means insect killer. Insecticides are employed for the protection of man, domestic, crops and agricultural products from insect depredations. To kill an insect with an insecticide, the poisonous chemical, usually most penetrate to vital organs and tissue of the insect. Certain insecticides penetrate rapidly through the body wall of some insect species. Other insects with the body wall thick, waxy, or, other size wall protected are likely to be resistant to direct penetration. In these it may be desirable for the insecticides to be taken in to the digestive tract along with food or water.

Insecticides were in use from very early times and as early as 200 B.C. boiling mixture of bitumen (mineral pitch or asphalt) and bellowing the fumes through grape leaves were advocated to keep away the insects.

**Classification of Insecticides:**

<table>
<thead>
<tr>
<th>Based on mode of entry</th>
<th>Based on chemical nature</th>
</tr>
</thead>
<tbody>
<tr>
<td>a- Stomach poisons</td>
<td>Natural insecticides</td>
</tr>
<tr>
<td>b- Contract poisons</td>
<td>Inorganic insecticides</td>
</tr>
<tr>
<td>c- Fumigents</td>
<td>Organic Insecticides,</td>
</tr>
</tbody>
</table>
d. Systemic insecticides

Based on the chemical nature of insecticides they are classified as natural, inorganic and organic.

1. **Natural Insecticides Control**: 

Natural control can be defined as any condition of the environment that checks insect population and can not be altered. Some factors (i) climate as temperature humidity, and air movement (ii) topography and land and water barriers, soil texture and composition and (iii) parasites and predators are responsible for natural control.

**Biological Control**: 

Biological control may be defined as the artificial manipulation of natural biological phenomenon for the purpose of reducing or checking destructive population of insects, other animals or plants.

2. **Inorganic Insecticides**: 

Industrial revolution has started with synthetic insecticides. In 1867 Paris green (copper acetoarsenate) was used as dust or spray. Leadarsenate, white arsenate and calcium arsenate comes under arsenicals. Lime sulphur and HCN were used for controlling scale insect. Chromates, thallium compounds and mercury compounds (cabbagemaggot) were also tried. Fluorine compounds were useful in cockroach and ant control. They have been known since 1842 (NaF,
Na$_3$SiF$_5$; Na$_3$AlF$_6$ and Borax). Although they are cheap and most effective, their continuous use involved considerable health hazards. They have been replaced by D.D.T. for lead arsenate, toxaphene and aldrine for calcium arsenate in cotton pest control.

3. **Organic insecticides:**

Made their appearance in modern era of insecticides with thiocyanates in 1930's. All alkyl thiocyanates are insecticidal (R-S-C=N). They act as contact insecticides when R is dodecyl and as fumigants when R is lower alkyl group. In 1936, lethane was introduced in U.S.A. Its development was ceased due to DDT's success. Thanite is the only compound used commercially.

These are the most important type of insecticides, whose action is very fast. Almost maximum percentages of insecticides used today are synthetic organic insecticides.

The synthetic organic insecticides are classified into:

a. Organophosphorus insecticides$^{20}$.

b. Carbamate insecticides$^{21}$.

c. Pyrethroid insecticides$^{22}$.

d. Chlorinate hydrocarbons$^{23}$.

e. Organotin compounds.

f. Acylurea compounds$^{24}$.

g. Formamidines$^{25}$.

h. Phosphine.

i. Ovicides of the clofentezine/hexythiazox type$^{26}$. 
Heterocyclic ring plays a major role in the synthesis of insecticides. Here are some of the commonly used insecticides, which have a heterocyclic ring in them.

1. **Carbosulfan**:

   Group – Carbamate

   ![Carbosulfan structure](image)

   IUPAC Name – 2,3-dihydro-2,2-dimethyl benzofuran-7-yl (dibutylaminothio) methyl carbamate.

   Mode of action – Cholinesterase inhibitor

   Use – It controls millipedes, springtails, symphyllids, wireworm’s pygmy, mongold, bettles, fruitflies, white grube, coloradobutles, codling moth etc.

2. **Chlorfluazuron**:

   Group – Benzoyl urea

   ![Chlorfluazuron structure](image)

   IUPAC Name – 1-[3’,5’-dichloro-4’-(3”-chloro-5” tri fluoromethyl-2”-pyridyloxy) –3-[2”’, 6” difluoro benzoyl] urea.
Mode of action: Insect growth regulator which acts as an anti-moulding agent.

Use – Its control includes Heliothis, Spodoptera, Bemisia tobaci and other chewing insects on cotton.

3. **Diazinone**\(^{30}\):

Group – Organophosphorus

\[
\begin{align*}
\text{H}_3\text{C} & \quad \text{S} \\
\text{N} & \quad \text{OP(OC}_2\text{H}_3\text{)}_2 \\
(\text{CH}_3)_2\text{CH} & \\
\end{align*}
\]

IUPAC Name – \(\alpha,\alpha\)-diethyl \(\alpha\)-2-isopropyl-6-methyl pyrimidin-4-yl phosphorothioate.

Mode of action – Non-systemic insecticides and acaricide. It is a cholinesterase inhibitor.

Use – Controls sucking and chewing of insects and mites. It is also used as a veterinary ectoparasiticides.

4. **Fipronil**\(^{31}\):

Group – Phenyl Pyrazole

\[
\begin{align*}
\text{F}_3\text{C} & \quad \text{N} \\
\text{Cl H}_2\text{N} & \quad \text{S} = \text{O} \\
\end{align*}
\]

IUPAC Name – \((\pm)\) 5-amino-1-(2', 6', dichloro-\(\alpha, \alpha\)-\(\alpha\)-tri-fluoro-p-tolyl) – 4-trifluoro methyl sulfinyl pyrazole-3- carbonitrile.
Mode of action – Insecticides, which acts as a potent blocker of the GABA, regulated chloride channel.

Use – Control of many soil and foliar insects.

5. **Imidaclopride**\(^{32}\):

   Group – Pyridyl imidazole

   ![Imidaclopride structure](structure.png)

   IUPAC Name – 1-(6'-chloro-3'-pyridyl methyl) N-nitroimidazolidin-2-yl ideneamine.

   Mode of action – Acts on the CNS, causing irreversible blockage of past synaptic nicotinergic acetylcholine receptors.

   Use – It controls sucking insects, rice hoppers, aphids, thrips and white flies.

6. **Quinalphos**\(^{33}\):

   Group – Organophosphorus

   ![Quinalphos structure](structure.png)

   IUPAC Name – o,o-diethyl o-quinoxalin-2-yl phosphorothioate.

   Mode of action – Insecticide and acaricide with contact and stomach action.
Use – Control of many insect pests of the orders Lepidoptera, Coleoptera, Diptera, Hemiptera etc.

7. **Triazamate**:  

Group – Carbamate  

\[
\text{\begin{array}{c}
\text{(CH}_3\text{)}_3\text{C} \text{N} \text{N} \text{CON} \text{C}_3 \\
\text{SCH}_2 \text{COOCH}_2 \text{- CH}_3
\end{array}}
\]

IUPAC Name – Ethyl (3-tert-butyl-1-dimethyl carba-moyl-1H-1,2,4-triazol-5yl thio) acetate.

Mode of action: Fast acting non-fumigant selective aphicide with contact and systemic action.

Use – It controls aphids including those resistant to carbamate and organo phosphorus insecticides.

8. **Phoslone**\(^{34}\) :  

Group- Organophosphorus  

\[
\text{\begin{array}{c}
\text{Cl} \text{- O} \text{- S} \text{- P} \text{- (OCH}_2 \text{- CH}_3)_2
\end{array}}
\]

IUPAC Name – S-6-chloro-2,3-dihydro-2-oxo benzoazol-3-yl methyl o,o-diethyl phosphorodithioate.

Mode of action: None systemic insecticides and acaricide showing localized penetration of plant cuticle, with contact and stomach action.

Use – Control of many insect pests of the orders lepidoptera etc.
9. Hydromethylnone:

Group – Organtoin

\[
\begin{align*}
\text{H}_3\text{C} & \text{H} \\
\text{H}_3\text{C} & \text{N} \equiv \text{N} \equiv \text{C} \\
\text{N} & \text{C} = \text{C} \\
\text{C} & \text{H} \quad \text{C} = \text{C} \\
\text{C} & \text{H} \quad \text{N} \equiv \text{N} \equiv \text{C} \\
\text{C} & \text{H} \quad \text{H} \\
\text{C} & \text{H} \quad \text{H} \\
\text{C} & \text{H} \quad \text{H}
\end{align*}
\]

IUPAC Name – 5,5-dimethyl per hydro pyrimidine-2-one 4-tri fluoro methyl-α-(4-tri fluoro methyl styryl) cinnamylidenehydrazone.

Mode of action – Non-systematic insecticides with stomach action.

Use – Selective control of agricultural and household formicides.

**MATERIAL AND METHODS**

Cockroaches were selected for the present investigation 2% (w/v) and 4% (w/v) solution of synthesized compounds of quinoline, pyrazoline, indole and carbazole and its complexes compounds with Cu, and Co metals have been prepared in acetone. 4% solution (1-2 millimoles of solution) of synthesized compounds was injected in to the abdominal region of cockroach with the help of microsyringe. The time of death was noted as KD value (Knock down values). At the time of death, the antennae become motionless the appendages shrunk and folded towards the ventral side and cockroach lay dorsally. For each sample four replications were performed and average KD value noted.
Standard: Cypermethrin is used as a control. Its 4% (w/v) solution has been prepared in acetone. It belongs to pyrethroid group.

Mode of action: Non-systemic insecticides with contact and stomach action also exhibits antifeeding action.

Use: Control of wide range of insects, especially lepidoptera, coleoptera, diptera and hemiptera. Control of flies and other insects in animal houses and mosquitoes, cockroaches, houseflies and other insect in public health. It is also used as animal ectoparasiticide.

The KD value for the control Cypermethrin was 8 minutes. The KD value of synthesized compounds was compared with control drug. Data represented in table.
### Table No. 1

<table>
<thead>
<tr>
<th>Compound Code of Synthesized Compounds</th>
<th>Insecticidal activity of Pyrazoline derivatives, K.D. value in [minutes]</th>
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<td></td>
<td>Complex with Cobalt</td>
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<tr>
<td></td>
<td>Comp.Code Time (Min)</td>
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<td>16 AP 39 14</td>
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<tr>
<td>AP 2</td>
<td>12.5 AP 40 10</td>
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<td>AP 5</td>
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<td>AP 8</td>
<td>15 AP 46 13</td>
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<td>AP 9</td>
<td>16 AP 47 14</td>
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<td>AP 10</td>
<td>14 AP 48 12.5</td>
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<td>13.5 AP 49 12</td>
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<td>12 AP 50 10</td>
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<td>Complex with Cobalt</td>
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<td>Comp. Code</td>
</tr>
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<td>10</td>
</tr>
<tr>
<td>AP 14</td>
<td>11</td>
<td>AP 52</td>
<td>9</td>
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<td>AP 15</td>
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<td>AP 55</td>
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<td>14</td>
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## Table No. 3

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<td>Complex with Copper</td>
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<tr>
<td></td>
<td>Comp. Code</td>
<td>Time (Min)</td>
<td>Comp. Code</td>
</tr>
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<td>12.5</td>
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<td>AP 27</td>
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<td>AP 69</td>
<td>12.5</td>
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Table No. 4

<table>
<thead>
<tr>
<th>Compound Code of Synthesized Compounds</th>
<th>Time (Min)</th>
<th>Complex with Cobalt</th>
<th>Complex with Copper</th>
</tr>
</thead>
<tbody>
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<td></td>
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<td>Comp. Code</td>
<td>Time (Min)</td>
</tr>
<tr>
<td>AP 33</td>
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</tbody>
</table>

RESULT AND DISCUSSION

In the pyrazoline group the compounds AP2, AP5 and AP12 have shown more activity than the rest, and its complex compounds with Copper metal have shown more activity than standard drug.

In the quinoline group the chloro and nitro derivatives have shown more potential and copper containing complexes have shown more activity than standard drug (cypermehrin).

In the Indole group compound AP26 and its complexes with cobalt, and copper metal have exhibited more activity than standard drug and compound AP27, AP28, and AP32 have exhibited more efficacy than rest compounds.

In the Carbazole group the compounds AP25 and AP28 and its copper metal complexes have shown more activity than standards drug and rest compounds.
SUMMARY

4% (w/v) solutions of synthesized compounds have been prepared in acetone. Similarly 4% (w/v) solution of cypermethrin as standard drug was also prepared in acetone. The test sample solutions were injected into the abdominal region of the cockroach. The time of death is noted on an average. The time of death is known as KD value (knock down value).

The chloro- and nitro- derivatives have exhibited good activity than the rest of the compounds. The activity of heterocyclic compounds was found better than their copper and cold complexes.
REFERENCE


27. R.S. Cahn, C. Ingold and V. Prelog, "*Experientia*", 2, 81, 1956.


