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SPECTRAL AND TOPOLOGICAL CHARACTERISTICS OF INSECTILE GRAPH

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Abstract

Insects are invertebrate species of the Insecta class, within the Phylum Arthropoda, the largest and (on land) most widely distributed taxon.
More than half (approximately 57 percent) of all animal species known are insects, and some authorities claim that less than 10 percent of living insect species have actually been described and named. In this paper we have tried to discover a mathematical approach towards them. The insects are divided into 4 categories and their graphs called the Insectile graph are obtained for the first time. Adjacency Matrix of the graph and the corresponding eigen values are calculated. Various topological indices like first and second Zagreb index, modified and Redefined Zagreb index, Harmonic index and Inverse sum index are calculated.

Keywords: Insects, Insectile Graph, Topological Indices, Spectral Properties, Adjacency matrix

Introduction and Preliminaries

Insects (from Latin *insectum*) are pan crustacean hexapod invertebrates of the class **Insecta** and are the largest group within the arthropod phylum. Insects have a chitinous exoskeleton, a three-part body (head, thorax and abdomen), three pairs of jointed legs, compound eyes and one pair of antennae. Insects are the most diverse group of animals; they include more than a million described species and represent more than half of all known living organisms. The total number of extant species is estimated at between six and ten million; potentially over 90% of the animal life forms on Earth are insects. Insects may be found in nearly all environments, although only a small number of species reside in the oceans, which are dominated by another arthropod group, crustaceans, which recent research has indicated insects are nested within.

Nearly all insects hatch from eggs. Insect growth is constrained by the inelastic exoskeleton and development involves a series of molts. The immature stages often differ from the adults in structure. Adult insects typically move about by walking, flying, or sometimes swimming. Insects are the only invertebrate group with members able to achieve sustained powered flight, and all flying insects derive from one common ancestor.

Insect pollinators are essential to the life cycle of many flowering plant species on which most organisms, including humans, are at least partly dependent; without them, the terrestrial portion of the biosphere would be devastated. Many insects are considered ecologically beneficial as predators and a few provide direct economic benefit. Silkworms produce silk and honey bees produce honey, and both have been domesticated

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by humans. Insects are consumed as food in 80% of the world's nations, by people in roughly 3000 ethnic groups. [1,2,4]

To find a connection with mathematics, we have tried to establish a mathematical approach towards it by introducing "Insectile Graphs".

(The method to draw the graph is described below in detail)

Insectile Graph

Insectile graphs are a special type of graph that have their origins in the field of mathematics known as graph theory. Graph theory is the study of graphs, which are mathematical structures used to model pairwise relationships between objects. Insectile graphs are a type of planar graph that have a unique and interesting property: they can be drawn without any edge crossings, much like a drawing of an insect.

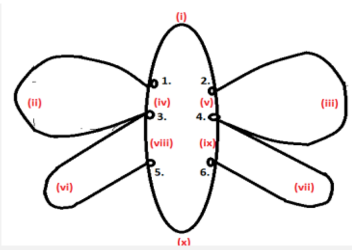
To understand what an insectile graph is, it is helpful to first understand some basic terminology of graph theory. A graph is a mathematical structure that consists of a set of vertices (also called nodes) and a set of edges (also called links or lines) that connect pairs of vertices. A planar graph is a graph that can be drawn on a plane in such a way that its edges do not cross each other.[3]

The name "insectile" comes from the fact that these graphs can be drawn in such a way that they resemble insects.

<u>Method to draw Insectile graph</u>

Insects primarily have 6 legs and 2 pair of wings. The Order Diptera (true flies) includes many common insects such as mosquitoes, midges, sand flies, blowflies and the House Fly., but dipterans (meaning 'two wings') use only one pair. The other pair of wings is reduced to club-like structures known as 'halteres' that they use for balance. The Order Diptera (true flies) includes many common insects such as mosquitoes, midges, sand flies, blowflies and the House Fly.

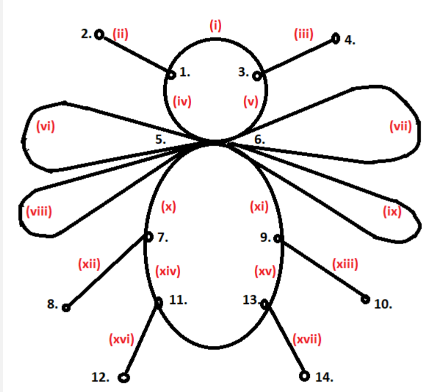
Insects have the ability to fly and crawl both. Based on what their prominent nature is, we have divided the insectile graphs into 4 parts – viz insects whose only significant parts are 4 wings i.e., they mostly fly **(W)**, insects with significant parts as legs and 4 wings i.e., they fly and crawl **(LW_4)**, insects with significant parts as legs and 2 wings i.e., they fly and crawl but have 2 wings instead of 4 **(LW_2)** and last, insects with significant parts as legs i.e., they mostly crawl **(L).**

I.	**Insects**		**Insectile Graph**
			
Butterfly	**Moth**	**Dragonfly**	**W**

II.	**Insects**		**Insectile Graph**
			
Grasshopper	**Wasp**	**Bee**	


Cricket


True Bug



LW_4

III. Insects


Crane Fly

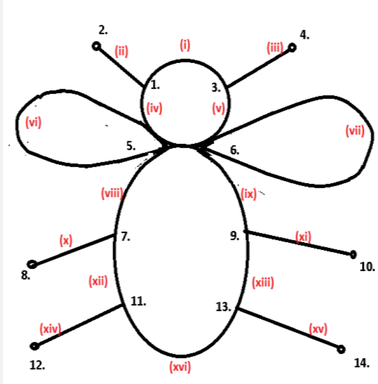

Horse Fly


Mosquito


Louse Fly


Bee Fly

Insectile Graph



LW_2

IV. Insects


Caterpillar

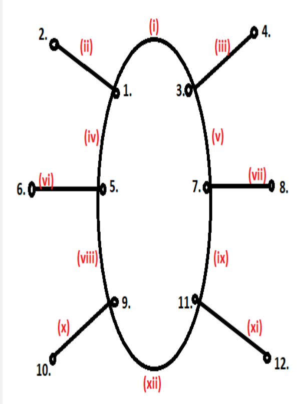

Ant


Beetle


Cockroach


Silverfish

Insectile Graph



L

For the above graphs we shall be discussing some of the Spectral and Topological Aspects:

Spectral Aspects

Adjacency matrix [5]

The adjacency matrix of a graph G with n vertices, $V(G) = \{v_1, ...v_n\}$ is a $n \times n$ matrix, denoted by $A(G) = (a_{ij})$, and is defined by

$$a_{ij} = \begin{cases} \text{no. of edges between } v_i \text{ and } v_j & \text{if vi is adjacent to vj,} \\ 0 & \text{otherwise.} \end{cases}$$

Note- A loop is counted as 2 edges.

Topological Indices

A topological index is a function that characterizes the topology of the graph. Most commonly known invariants of such kinds are degree-based indices. These are actually the numerical values that correlate the structure with various physical properties reactivity, and biological activities [2, 3, 12, 17, 19].

First Zagreb Index [1]: In 1972, Gutman &Trinajsti´c proposed the first Zagreb index defined by

$M_1 (G) = \sum_{u,v\in E} d(u) + d(v)$

Second Zagreb Index [1]: In 1972, Gutman &Trinajsti´c proposed the second Zagreb index defined by

$M_2 (G) =\sum_{u,v\in E} d(u).d(v)$

Modified Second Zagreb Index [13]: In 2003, Nikolic et al. Introduced Modified Second Zagreb Index defined by

$MM_2 (G) = \sum_{u,v\in E} \frac{1}{d(u).d(v)}$

Redefined III Zagreb Index [16]: In 2013, Ranjini et al. Introduced Redefined III Zagreb Index defined by

$ReZ (G) = \sum_{u,v\in E} d(u).d(v)[d(u) + d(v)]$

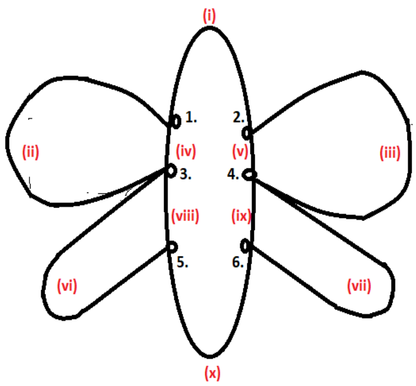
Harmonic Index [6]: In 1987, S. Fajtlowicz purposed another index called harmonic index H(G) defined as

$H (G) =\sum_{u,v\in E} \frac{1}{d(u)+d(v)}$

Inverse sum Index [18]: The inverse sum index that was selected as a significant predictor of total surface area of octane isomers in 2010, is defined as

$ISI (G) =\sum_{u,v\in E} \frac{d(u).d(v)}{d(u)+d(v)}$

Proposition 1: Insectile graph 'W'



Degrees of Vertices
d (1) =3
d (2) =3
d (3) =4
d (4) =4
d (5) =3
d (6) =3

No. of Vertices = 6	No. of Edges = 10

Topological indices of W_4

1. M1(G) (First Zagreb)

- $[d(1) + d(3)] + [d(2) + d(4)] + [d(3) + d(5)] + [d(4) + d(6)] + d(1) + d(2)] + [d(1) + d(3)] + [d(2) + d(4)] + [d(3) + d(5)] + [d(4) + d(6)] + [d(5) + d(6)] = 68$

2. M2(G) (Second Zagreb)
   - $[d(1).d(3)] + [d(2).d(4) + [d(3).d(5)] + [d(4).d(6)] + [d(1).d(2)] + [d(1).d(3)] + [d(2).d(4)] + [d(3).d(5)] + [d(4).d(6)] + [d(5).d(6)]$=114

3. MM2(G) (Modified Second Zagreb)
   - $\frac{1}{d(1).d(3)} + \frac{1}{d(2).d(4)} + \frac{1}{d(3).d(5)} + \frac{1}{d(4).d(6)} + \frac{1}{d(1).d(2)} + \frac{1}{d(1).d(3)} + \frac{1}{d(2).d(4)} + \frac{1}{d(3).d(5)} + \frac{1}{d(4).d(6)} + \frac{1}{d(5).d(6)}$ =8/9

4. ReZ(G) (Redefined Third Zagreb)
   - $\{d(1).d(3)[d(1) + d(3)]\} + \{d(2).d(4)[d(2) + d(4)\{d(3).d(5)[d(3) + d(5)]\} + \{d(4).d(6)[d(4) + d(6)]\} + \{d(1).d(2)[d(1) + d(2)]\} + \{d(1).d(3)[d(1) + d(3)]\} + \{d(2).d(4)[d(2) + d(4)]\} + \{d(3).d(5)[d(3) + d(5)]\} + \{d(4).d(6)[d(4) + d(6)]\} + \{d(5).d(6)[d(5) + d(6)]\}$ = 780

5. H(G) (Harmonic Index)
   - $\frac{1}{d(1)+d(3)} + \frac{1}{d(2)+d(4)} + \frac{1}{d(3)+d(5)} + \frac{1}{d(4)+d(6)} + \frac{1}{d(1)+d(2)} + \frac{1}{d(1)+d(3)} + \frac{1}{d(2)+d(4)} + \frac{1}{d(3)+d(5)} + \frac{1}{d(4)+d(6)} + \frac{1}{d(5)+d(6)}$ = 31/21

6. ISI(G) (Inverse Sum Index)
   - $\frac{d(1).d(3)}{d(1)+d(3)} + \frac{d(2).d(4)}{d(2)+d(4)} + \frac{d(3).d(5)}{d(3)+d(5)} + \frac{d(4).d(6)}{d(4)+d(6)} + \frac{d(1).d(2)}{d(1)+d(2)} + \frac{d(1).d(3)}{d(1)+d(3)} + \frac{d(2).d(4)}{d(2)+d(4)} + \frac{d(3).d(5)}{d(3)+d(5)} + \frac{d(4).d(6)}{d(4)+d(6)} + \frac{d(5).d(6)}{d(5)+d(6)}$ = 117/7

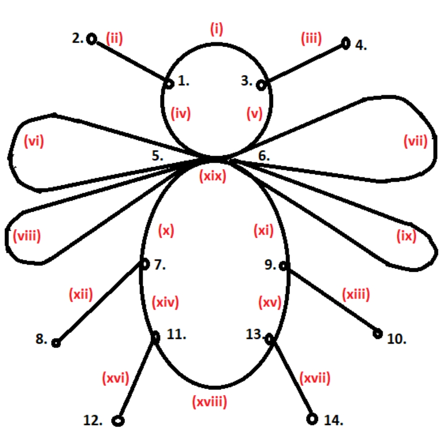
Adjacency matrix of W_4 (A(W))

0	1	2	0	0	0
1	0	0	2	0	0
2	0	0	0	2	0
0	2	0	0	0	2
0	0	2	0	0	1
0	0	0	2	1	0

Eigen Values of A(W_4)

-3.3723, -2.3723, -1.0000, 1.0000, 2.3723, 3.3723

Proposition 2: Insectile graph 'LW_4'



No. of Vertices = 14 No. of Edges = 19

Degrees of Vertices

d (1) =3	d (8) =1
d (2) =1	d (9) =3
d (3) =3	d (10) =1
d (4) =1	d (11) =3
d (5) =7	d (12) =1
d (6) =7	d (13) =3
d (7) = 3	d (14) =1

Topological indices of W_4

1. $M_1(G)$ (First Zagreb)
    - $[d(1)+d(3)]+[d(1)+d(2)]+[d(3)+d(4)]+[d(1)+d(5)]+d(3)+d(6)]+[d(5)+d(5)]+[d(6)+d(6)]+[d(5)+d(5)]+[d(6)+d(6)]+[d(5)+d(7)]+d(6)+d(9)]+[d(8)+d(7)]+[d(9)+d(10)]+[d(7)+d(11)]+[d(9)+d(13)]+[d(11)+d(12)])]+[d(13)+d(14)]+[d(13)+d(11)]\ +[d(5)+d(6)]$ = 158

2. $M_2(G)$ (Second Zagreb)
    - $[d(1).d(3)]+[d(1).d(2)]+[d(3).d(4)]+[d(1).d(5)]+[d(3).d(6)]+[d(5).d(5)]+[d(6).d(6)]+[d(5).d(5)]+[d(6).d(6)]+[d(5).d(7)]+[d(6).d(9)]+[d(8).d(7)]+[d(9).d(10)]+[d(7).d(11)]+[d(9).d(13)]+[d(11).d(12)])]+[d(13).d(14)]+[d(13).d(11)]+[d(5).d(6)]$ = 383

3. $MM_2(G)$ (Modified Second Zagreb)
    - $\frac{1}{d(1).d(3)}+\frac{1}{d(1).d(2)}+\frac{1}{d(3).d(4)}+\frac{1}{d(1).d(5)}+\frac{1}{d(3).d(6)}+\frac{1}{d(5).d(5)}+\frac{1}{d(6).d(6)}+\frac{1}{d(5).d(5)}+\frac{1}{d(6).d(6)}+\frac{1}{d(5).d(7)}+\sum_{(u,v)\in E}\frac{1}{d(6).d(9)}+\frac{1}{d(8).d(7)}+\frac{1}{d(9).d(10)}+\frac{1}{d(7).d(11)}+\frac{1}{d(9).d(13)}+\frac{1}{d(11).d(12)}+\frac{1}{d(13).d(14)}+\frac{1}{d(13).d(11)}+\frac{1}{d(5).d(6)}$
    = 8449/3086

4. ReZ(G) (Redefined Third Zagreb)
    - $\{d(1).d(3)[d(1)+d(3)]\}+\{d(1).d(2)[d(1)+d(2)]\}+\{d(3).d(4)[d(3)+d(4)]\}+\{d(1).d(5)[d(1)+d(5)]\}+\{d(3).d(6)[d(3)+d(6)]\}+\{d(5).d(5)[d(5)+d(5)]\}+\{d(6).d(6)[d(6)+d(6)]\}+\{d(5).d(5)[d(5)+d(5)]\}+\{d(6).d(6)[d(6)+d(6)]\}+\{d(5).d(7)[d(5)+d(7)]\}+\{d(6).d(9)[d(6)+d(9)]\}+\{d(8).d(7)[d(8)+d(7)]\}+\{d(9).d(10)[d(9)+d(10)]\}+\{d(7).d(11)[d(7)+d(11)]\}+\{d(9).d(13)[d(9)+d(13)]\}+\{d(11).d(12)[d(11)+d(12)]\}+\{d(13).d(14)[d(13)+d(14)]\}+\{d(13).d(11)[d(13)+d(11)]\}+\{d(5).d(6)[d(5)+d(6)]\}$ = 4558

5. H(G) (Harmonic Indexe)
    - $\frac{1}{d(1)+d(3)}+\frac{1}{d(1)+d(2)}+\frac{1}{d(3)+d(4)}+\frac{1}{d(1)+d(5)}+\frac{1}{d(3)+d(6)}+\frac{1}{d(5)+d(5)}+\frac{1}{d(6)+d(6)}+\frac{1}{d(5)+d(5)}+\frac{1}{d(6)+d(6)}+\frac{1}{d(5)+d(7)}+\frac{1}{d(6)+d(9)}+\frac{1}{d(8)+d(7)}+\frac{1}{d(9)+d(10)}+\frac{1}{d(7)+d(11)}+\frac{1}{d(9)+d(13)}+\frac{1}{d(11)+d(12)}+\frac{1}{d(13)+d(14)}+\frac{1}{d(13)+d(11)}+\frac{1}{d(5)+d(6)}$ = 307/105

6. ISI(G) (Inverse Sum Index)
    - $\frac{d(1).d(3)}{d(1)+d(3)}+\frac{d(1).d(2)}{d(1)+d(2)}+\frac{d(3).d(4)}{d(3)+d(4)}+\frac{d(1).d(5)}{d(1)+d(5)}+\frac{d(3).d(6)}{d(3)+d(6)}+\frac{d(5).d(5)}{d(5)+d(5)}+\frac{d(6).d(6)}{d(6)+d(6)}+\frac{d(5).d(5)}{d(5)+d(5)}+\frac{d(6).d(6)}{d(6)+d(6)}+\frac{d(5).d(7)}{d(5)+d(7)}+\frac{d(6).d(9)}{d(6)+d(9)}+\frac{d(6).d(9)}{d(8)+d(7)}+\frac{d(9).d(10)}{d(9)+d(10)}+\frac{d(7).d(11)}{d(7)+d(11)}+\frac{d(9).d(13)}{d(9)+d(13)}+\frac{d(11).d(12)}{d(11)+d(12)}+\frac{d(13).d(14)}{d(13)+d(14)}+\frac{d(13).d(11)}{d(13)+d(11)}+\frac{d(5).d(6)}{d(5)+d(6)}$ = 182/5

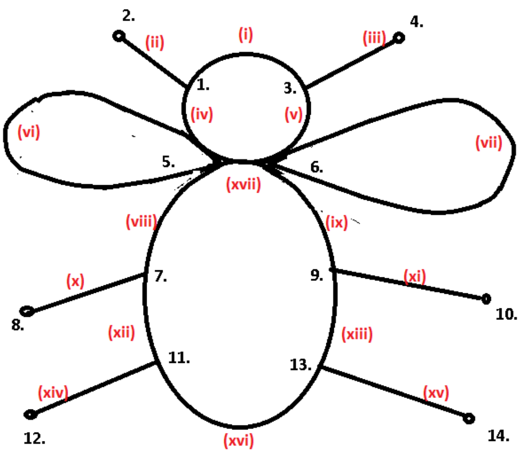
Adjacency Matrix of LW_4 ($A(LW_4)$

0	1	1	0	1	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	1	0	1	0	0	0	0	0	0	0	0
0	0	1	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	4	1	1	0	0	0	0	0	0	0
0	0	1	0	1	4	0	0	1	0	0	0	0	0
0	0	0	0	1	0	0	1	0	0	1	0	0	0
0	0	0	0	0	0	1	0	0	0	0	0	0	0
0	0	0	0	0	1	0	0	0	1	0	0	1	0
0	0	0	0	0	0	0	0	1	0	0	0	0	0
0	0	0	0	0	0	1	0	0	0	0	1	1	0
0	0	0	0	0	0	0	0	0	0	1	0	0	0
0	0	0	0	0	0	0	0	1	0	1	0	0	1
0	0	0	0	0	0	0	0	0	0	0	0	1	0

Eigen Values of $A(LW_4)$

-2.1615, -1.7654, -1.4389, -0.7957, -0.6683, -0.4841,0.4348,0.5363, 0.6722, 1.1897, 1.4335, 2.0509, 3.5617, 5.4346

Proposition 3: Insectile graph 'LW_2'



Degrees of Vertices	
d (1) =3	d (8) =1
d (2) =1	d (9) =3
d (3) =3	d (10) =1
d (4) =1	d (11) =3
d (5) =5	d (12) =1
d (6) =5	d (13) =3
d (7) = 3	d (14) =1

No. of Vertices = 14 No. of edges = 17

Topological indices of LW_2

1. $M_1(G)$ (First Zagreb)
   - $[d(1)+d(3)]+[d(1)+d(3)]+[d(1)+d(2)]+[d(3)+d(4)]+[d(1)+d(5)]+d(3)+d(6)]+[d(5)+d(5)]+[d(6)+d(6)]+[d(5)+d(7)]+d(6)+d(9)]+[d(8)+d(7)]+[d(9)+d(10)]+[d(7)+d(11)]+[d(9)+d(13)]+[d(11)+d(12)])]+[d(13)+d(14)]+[d(13)+d(11)]+[d(5)+d(6)]$ = 110

2. $M_2(G)$ (Second Zagreb)
   - $[d(1).d(3)]+[d(1).d(2]+[d(3).d(4)]+[d(1).d(5)]+[d(3).d(6)]+[d(5).d(5)]+[d(6).d(6)]+[d(5).d(7)]+[d(6).d(9)]+[d(8).d(7)]+[d(9).d(10)]+[d(7).d(11)]+[d(9).d(13)]+[d(11).d(12)])]+[d(13).d(14)]+[d(13).d(11)])]+[d(5).d(6)]$ = 177

3. $MM_2(G)$ (Modified Second Zagreb)
   - $\frac{1}{d(1).d(3)}+\frac{1}{d(1).d(2)}+\frac{1}{d(3).d(4)}+\frac{1}{d(1).d(5)}+\frac{1}{d(3).d(6)}+\frac{1}{d(5).d(5)}+\frac{1}{d(6).d(6)}+\frac{1}{d(5).d(7)}+\sum_{(u,v)\in E}\frac{1}{d(6).d(9)}+\frac{1}{d(8).d(7)}+\frac{1}{d(9).d(10)}+\frac{1}{d(7).d(11)}+\frac{1}{d(9).d(13)}+\frac{1}{d(11).d(12)}+\frac{1}{d(13).d(14)}+\frac{1}{d(13).d(11)}+\frac{1}{d(5).d(6)}$ = 229/75

4. ReZ(G) (Redefined Third Zagreb)
   - $\{d(1).d(3)[d(1)+d(3)]\}+\{d(1).d(2)[d(1)+d(2)]\}+\{d(3).d(4)[d(3)+d(4)]\}+\{d(1).d(5)[d(1)+d(5)]\}+\{d(3).d(6)[d(3)+d(6)]\}+\{d(5).d(5)[d(5)+d(5)]\}+\{d(6).d(6)[d(6)+d(6)]\}+\{d(5).d(7)[d(5)+d(7)]\}+\{d(6).d(9)[d(6)+d(9)]\}+\{d(8).d(7)[d(8)+d(7)]\}+\{d(9).d(10)[d(9)+d(10)]\}+\{d(7).d(11)[d(7)+d(11)]\}+\{d(9).d(13)[d(9)+d(13)]\}+\{d(11).d(12)[d(11)+d(12)]\}+\{d(13).d(14)[d(13)+d(14)]\}+\{d(13).d(11)[d(13)+d(11)]\}+\{d(5).d(6)[d(5)+d(6)]\}$ = 1518

5. H(G) (Harmonic Index)
   - $\frac{1}{d(1)+d(3)}+\frac{1}{d(1)+d(2)}+\frac{1}{d(3)+d(4)}+\frac{1}{d(1)+d(5)}+\frac{1}{d(3)+d(6)}+\frac{1}{d(5)+d(5)}+\frac{1}{d(6)+d(6)}+\frac{1}{d(5)+d(7)}+\frac{1}{d(6)+d(9)}+\frac{1}{d(8)+d(7)}+\frac{1}{d(9)+d(10)}+\frac{1}{d(7)+d(11)}+\frac{1}{d(9)+d(13)}+\frac{1}{d(11)+d(12)}+\frac{1}{d(13)+d(14)}+\frac{1}{d(13)+d(11)}+\frac{1}{d(5)+d(6)}$ = 25/6

6. ISI(G) (Inverse Sum Index)
   - $\frac{d(1).d(3)}{d(1)+d(3)}+\frac{d(1).d(2)}{d(1)+d(2)}+\frac{d(3).d(4)}{d(3)+d(4)}+\frac{d(1).d(5)}{d(1)+d(5)}+\frac{d(3).d(6)}{d(3)+d(6)}+\frac{d(5).d(5)}{d(5)+d(5)}+\frac{d(6).d(6)}{d(6)+d(6)}+\frac{d(5).d(7)}{d(5)+d(7)}+\frac{d(6).d(9)}{d(6)+d(9)}+\frac{d(6).d(9)}{d(8)+d(7)}+\frac{d(9).d(10)}{d(9)+d(10)}+\frac{d(7).d(11)}{d(7)+d(11)}+\frac{d(9).d(13)}{d(9)+d(13)}+\frac{d(11).d(12)}{d(11)+d(12)}+\frac{d(13).d(14)}{d(13)+d(14)}+\frac{d(13).d(11)}{d(13)+d(11)}+\frac{d(5).d(6)}{d(5)+d(6)}$ = 51/2

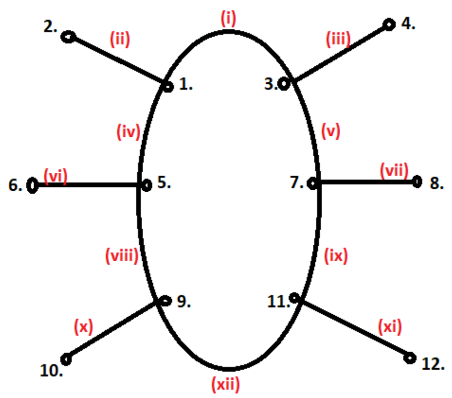
Adjacency matrix of LW_2 ($A(LW_2)$)

0	1	1	0	1	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	1	0	1	0	0	0	0	0	0	0	0
0	0	1	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	2	1	1	0	0	0	0	0	0	0
0	0	1	0	1	2	0	0	1	0	0	0	0	0
0	0	0	0	1	0	0	1	0	0	1	0	0	0
0	0	0	0	0	0	1	0	0	0	0	0	0	0
0	0	0	0	0	1	0	0	0	1	0	0	1	0
0	0	0	0	0	0	0	0	1	0	0	0	0	0
0	0	0	0	0	0	1	0	0	0	0	1	1	0
0	0	0	0	0	0	0	0	0	0	1	0	0	0
0	0	0	0	0	0	0	0	1	0	1	0	0	1
0	0	0	0	0	0	0	0	0	0	0	0	1	0

Eigen Values of $A(LW_2)$

-2.2327, -1.8426, -1.4823, -0.8394, -0.6949, -0.4866, 0.2678, 0.5048, 0.6119, 1.0000, 1.2941, 2.0252, 2.1421, 3.7326

Proposition 4: Insectile graph 'L'



Degrees of Vertices	
d (1) =3	d (7) =3
d (2) =1	d (8) =1
d (3) =3	d (9) =3
d (4) =1	d (10) =1
d (5) =3	d (11) =3
d (6) =1	d (12) =1

No. of Vertices = 12 No. of Edges =12

Topological indices of L

1. $M_1(G)$ (First Zagreb)
   - $[d(1)+d(3)]+[d(1)+d(2)]+[d(3)+d(4)]+[d(1)+d(5)]+[d(3)+d(7)]+[d(5)+d(6)]+[d(7)+d(8)]+[d(5)+d(9)]+[d(7)+d(11)]+[d(10)+d(9)]+[d(11)+d(12)])]+[d(9)+d(11)]=60$

2. $M_2(G)$ (Second Zagreb)
   - $[d(1).d(3)]+[d(1).d(2)][d(3).d(4)]+[d(1).d(5)]+[d(3).d(7)]+[d(5).d(6)]+[d(7).d(8)]+[d(5).d(9)]+[d(7).d(11)]+[d(10).d(9)]+[d(11).d(12)])]+[d(9).d(11)]=72$

3. $MM_2(G)$ (Modified Second Zagreb)

- $\frac{1}{d(1).d(3)}+\frac{1}{d(1).d(2)}+\frac{1}{d(3).d(4)}+\frac{1}{d(1).d(5)}+\frac{1}{d(3).d(7)}+\frac{1}{d(5).d(6)}+\frac{1}{d(7).d(8)}+\frac{1}{d(5).d(9)}+\frac{1}{d(7).d(11)}+\frac{1}{d(10).d(9)}+\frac{1}{d(11).d(12)}+\frac{1}{d(9).d(11)}=8/3$

4. ReZ(G) (Redefined Third Zagreb)
   - $\{d(1).d(3)[d(1)+d(3)]\}+\{d(1).d(2)[d(1)+d(2)\}+\{d(3).d(4)[d(3)+d(4)]\}+\{d(1).d(5)[d(1)+d(5)]\}+\{d(3).d(7)[d(3)+d(7)]\}+\{d(5).d(6)[d(5)+d(6)]\}+\{d(7).d(8)[d(7)+d(8)]\}+\{d(5).d(9)[d(5)+d(9)]\}+\{d(7).d(11)[d(7)+d(11)]\}+\{d(10).d(9)[d(10)+d(9)]\}+\{d(11).d(12)[d(11)+d(12)]\}+\{d(9).d(11)[d(9)+d(11)]\}=396$

5. H(G) (Harmonic Index)
   - $\frac{1}{d(1)+d(3)}+\frac{1}{d(1)+d(2)}+\frac{1}{d(3)+d(4)}+\frac{1}{d(1)+d(5)}+\frac{1}{d(3)+d(7)}+\frac{1}{d(5)+d(6)}+\frac{1}{d(7)+d(8)}+\frac{1}{d(5)+d(9)}+\frac{1}{d(7)+d(11)}+\frac{1}{d(10)+d(9)}+\frac{1}{d(11)+d(12)}+\frac{1}{d(9)+d(11)}=5/2$

6. ISI(G) (Inverse Sum Index)
   - $+\frac{d(1).d(3)}{d(1)+d(3)}+\frac{d(1).d(2)}{d(1)+d(2)}\frac{d(3).d(4)}{d(3)+d(4)}+\frac{d(1).d(5)}{d(1)+d(5)}+\frac{d(3).d(7)}{d(3)+d(7)}+\frac{d(5).d(6)}{d(5)+d(6)}+\frac{d(7).d(8)}{d(7)+d(8)}+\frac{d(5).d(9)}{d(5)+d(9)}+\frac{d(7).d(11)}{d(7)+d(11)}+\frac{d(10).d(9)}{d(10)+d(9)}+\frac{d(11).d(12)}{d(11)+d(12)}+\frac{d(9).d(11)}{d(9)+d(11)}=27/2$

<u>Adjacency Matrix of L (A(L))</u>

0	1	1	0	1	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0
1	0	0	1	0	0	1	0	0	0	0	0
0	0	1	0	0	0	0	0	0	0	0	0
1	0	0	0	0	1	0	0	1	0	0	0
0	0	0	0	1	0	0	0	0	0	0	0
0	0	1	0	0	0	0	1	0	0	1	0
0	0	0	0	0	0	1	0	0	0	0	0
0	0	0	0	1	0	0	0	0	1	1	0
0	0	0	0	0	0	0	0	1	0	0	0
0	0	0	0	0	0	1	0	1	0	0	1
0	0	0	0	0	0	0	0	0	0	1	0

<u>Eigen Values of A(L)</u>

-2.4142, -1.6180, -1.6180, -0.6180, -0.6180, -0.4142, 0.4142, 0.6180, 0.6180, 1.6180, 1.6180, 2.4142

Conclusion:

Insectile graphs is a fascinating inter disciplinary field of Entomology and Mathematics. Their insect-like appearance makes them fun to study and they can be proven useful in a variety of fields in future.

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