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Plain Tiger Butterfly (*Danaus chrysippus*) Lepidopterarium, As a Bio-entrepreneurship Model

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Abstract. The integration of bio-sciences and business is known as bio-entrepreneurship. It is the transfer of innovation from academy to business. A good bio-entrepreneur applies scientific methods to launch a business. This study explored bio-entrepreneurship opportunities in the field of biology, with the plain tiger butterfly as a representative business model. The Lepidopterarium breeds and displays butterflies while educating visitors. To grow Lepidopterarium, bio-entrepreneur must have some knowledge about butterflies. Butterflies have emerged as a critical player in addressing environmental challenges by serving as an indispensable climate indicator. In bio-entrepreneurship model the butterfly effect as a "real business model" rather than just a butterfly effect only in which life cycle of plain tiger butterfly as the representative. Every step of butterfly's life cycle is essential for different industries e.g., climate research labs, educational institutions, recreational tools, decor industries, tourism and even for the rituals.

Keywords: bio-entrepreneurship, business model, plain tiger butterfly, *Danaus chrysippus*, Lepidopterarium Pakistan

Introduction

The bio-entrepreneurship is a prominent topic in business management research due to its impact on other disciplines like science, arts and engineering (Kirzner, 2009). New bio economy is bio-entrepreneurship (Christopher and Kaur, 2011). In case of bio-entrepreneurship many sub-dimensions are making it challenging to develop a comprehensive grasp regarding its essential components (Ratten, 2023). The three main pillars of bio-entrepreneurship are management, capital and technology (Sinha *et al*., 2021). Research can assist businesses in making informed decisions. So, it is important to understand how small business managers and owners apply entrepreneurial thinking.

Human need is the main focus of bio-entrepreneurship. The need for business leaders is to adapt services, strategies and products that allow for an increase in both economic and social value in the context of today's global economy. Bio-entrepreneurship improves society on a large scale.Bio-entrepreneurship boosts capital, job creation, socio-economic benefits and environmental protection. Butterfly forming boots the rural economy's revenue (Wang, 2017).

Despite the potential growth benefits, Pakistan still has little bio-entrepreneurial activity. Government policy has traditionally prioritized large-scale manufacturing over small and medium-sized enterprises. The economic and socio-cultural environment has become difficult for bio-entrepreneurship and small businesses in Pakistan as a consequence.

The main objective of the present project is to offer opportunities in the field of biology as a bio-entrepreneurship model. In this study, the business model in which the plain tiger butterfly is representative. Because of their grace, beauty and sense of freedom, butterflies are considered as fascinating and recognizable garden creatures and a big attraction for the people. By serving as a pollinator, prey, biological pest control and environmental beautifier, butterflies maintain the ecosystem. (Rashida, 2020). The perceived link between butterfly forming profits and forest conservation encourage more people to engage in conservation activities (Morgan-Brown *et al*., 2010).

A Lepidopterarium is a space that has been designed specifically to rear butterflies and to provide them with the necessities for survival, such as food, sunlight, water and shelter (Tekulsky, 1985). Lepidopterarium is a delightful hobby that has advantages for people's bodies, minds, emotions and social lives. It is reported that buying a kit to raise live butterflies is an initial step for Lepidopterarium. Live butterfly kits include the caterpillars and all necessary instructions, as well as

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everything else needed to raise butterflies from the caterpillar to the adult butterfly through metamorphosis. It should be assured that flowers and plants used to attract butterflies should be the right kind for them to feed on and breed on. For creating Lepidopterarium, an understanding of the butterfly life cycle is important (Rashida, 2020).

Lepidopterarium is a facility designed specifically for the breeding and display of butterflies, with an emphasis on education. The owners and operators of Lepidopterariums include small, family-run enterprises, museums, universities and non-profit organizations. The plain tiger butterfly holds symbolism and cultural significance in different parts of the world. In some cultures, it is associated with transformation, renewal and rebirth, representing the cycles of life. The ability of the butterfly to undergo a complete metamor-phosis, emerging from a humble caterpillar to a magnificent winged creature, is often seen as a powerful symbol of personal growth and evolution.

Money matters for the initialization of a business but in the case of butterfly gardening, it requires a smaller initial investment. As far as availability of land, the initial cost will be lower. However, there are ongoing expenses associated with maintaining a Lepidopterarium, such as the cost of saplings, a gardener, honoraria for plant and butterfly experts (many of these roles can be filled by one person), electricity and water bills and so on (Kasambe, 2014). A successful bio-entrepreneurship balances management, capital and technology (Schoemaker and Schoemaker, 1998).

The present study is the first representation of Pakistan regarding bio-entrepreneurship, especially using butterfly as a model. In the present study, we analysed all three pillars of bio-entrepreneurship *i.e.* management, capital and technology by creating a plain tiger Lepidopterarium on a small scale.

Materials and Methods

Study region. The study was conducted on small scale at Virtual University which is situated in district Lahore, Pakistan from May to July, 2023. During the months of May to July, the average temperature ranges from 35 to 40 °C.

Materials required. A mosquito net, two host plants such as C*alotropis gigantea*, *Asclepias currassavica* and nine plain tiger butterflies, few nectar flowering plants, some honey solution (home made food for butterflies), few pupa kit, a measuring scale, a notepad, a pen and a camera used to start the plain tiger Lepidopterarium on a small scale. A disposable cup, a piece of net or tissue, a ruler and some leaves of the host plant are used to observe caterpillargrowth. The temperature by keeping these butterflies at room temperature maintained.

Collection. The plain tiger butterfly was collected samples using insect netting and hand collection from flowering plants, agricultural crops, fruit farms and fields in Lahore.

The plain tiger butterfly was identified by using an identification key (Perveen and Fazal, 2013). We identified freshly deposited eggs and the foliage. Then we carefully collected laid eggs without causing any harm. Subsequently, we transferred the material into a disposable cup measuring 10.5 cm in length and 9.5 cm in width, with a depth of 8.5 cm, as shown in Fig. 1. These

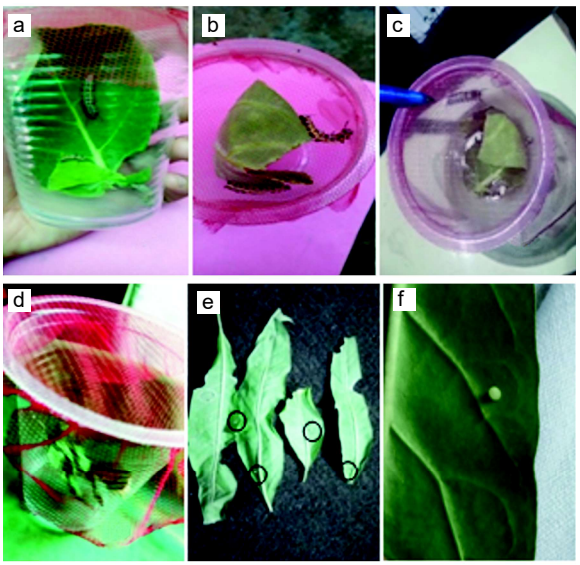


Fig. 1. The methods and materials (**a**) caterpillar placed in disposable cup with host plant leaves; closed the disposable cup with the help of net, (**b**) top view of caterpillar lived in a disposable cup, (**c**) pointing pre pupa attaching site (**d**) plain tiger eggs on leaves placed in a disposable cup and closed the disposable cup with the help of net for observation (**e**) plain tiger butterfly eggs found on *A. currassavica* (Shehzadi) host plant and (**f**) plain tiger egg found on *C. gigantean* (Aak) host plant.

eggs were then brought into a controlled environment at a standard temperature of 37 °C. The development of these eggs and the subsequent caterpillars was closely monitored. Fresh host plant leaves were provided as nourishment for the growing caterpillar and the numbers of developmental stages were duly documented. Noteworthy features such as the color and size of each stage were observed and recorded. As the caterpillar matured, it progressively required more sustenance and space.

Pupa hanging method. The mature caterpillar transformed into a pupa. For hanging a pupa in a certain area, the attached cotton to the solid surface where attach the pupa with the help of glue. Then, with the help of glue and attached also the pupa to the cotton of the solid surface. The pupa placed in the vertical position as shown in Fig. 2. Left it for 1 or 2 h in vertical position until the glue became dry and the pupa set there.

Some precautions used to hang a pupa and made that the pupa was attached by its abdomen side (posterior side) and made sure that pupa was in a vertical position to avoid damaging butterfly emergence. We didn't disturb Pupa's position and kept the butterfly head on the bottom side for perfect emergence.

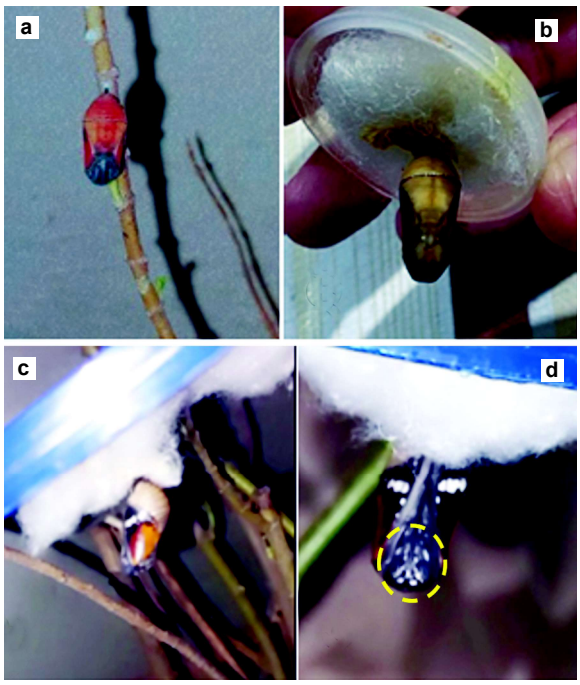


Fig. 2. The pupation method (**a**) pupa naturally hanged on a stem on its posterior side; (**b**) pupa attached indirectly to a solid surface in vertical position (**c**) plain tiger pupa left wing side view (**d**) the back side view of plain tiger butterfly pupa and pointing the head side of butterfly in pupa.

Pinning method. After the emergence of the plain tiger butterfly, when it died, them took it and pinned it. For pinning a plain tiger butterfly, which is utilized a beautiful plain tiger butterfly, a thermocol sheet, pins and tracing paper. We pinned the plain tiger butterfly to the surface of a thermocol sheet, a pin held to its thorax was pinned to a thermocol sheet, cut strips of tracing paper were inserted around the wings on the dorsal side, the wings were slightly spread on a thermocol sheet and the wing was pinned with the help of pins and tracing paper. Then inserted two pins crossed over each other to set the antennae in a "V" position, left in this position to dry for 1-2 days. Naphthalene beads were used to protect and preserve them from fungi, ants and other entomophages. When the wings had completely dried, the pins and paper strips were removed.

After pinning butterflies, the transferred butterflies into a display box to grab the attention of the customers, as shown in Fig. 3.

Fig. 3. The pinning method (**a**) plain tiger female and male butterfly pinning (**b**) outside view of display box of plain tiger butterfly (**c**) inside view of display box of plain tiger butterfly.

Results and Discussion

Plain tiger butterfly Lepidopterarium. In this study, developed a plain tiger butterfly Lepidopterarium at Virtual University in Lahore to observe the butterfly's developmental stages and gave an idea for the use of

the plain tiger butterfly as a bio-entrepreneur. The experiment was started by creating a Butterfly Lepidopterarium on a small scale, as shown in Fig. 4, where a plain tiger butterfly survived and went through its developmental stages. When we had some butterflies and put them in a mosquito net but when one butterfly left, then put it inside a basket with a net. We also provided a host plant for the butterfly.

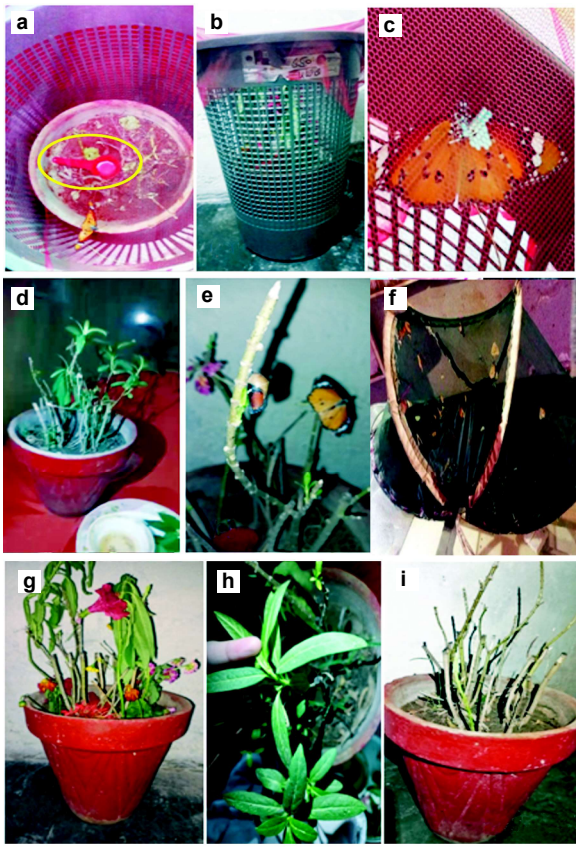


Fig. 4. Plain tiger grown on a small scale (**a**) upper view of a basket where a plain tiger butterfly placed with home made nectar kit (**b**) front view of a basket having a host plant and a plain tiger butterfly (**c**) ventral side of a plain tiger butterfly (**d**) inside view of plain tiger host plant having caterpillars in a large mosquito net (**e**) a plain tiger host plant having a pupa and a butterfly (**f**) small mosquito net and some plain tiger butterflies on a small scale (**g**) a plain tiger host plant with some real flowers attached with the help of rubber band for nectar purpose (**h**) the host plant before eaten by caterpillars (**i**) the host plant after eaten by four caterpillars within two days.

Plain tiger butterfly (*Danaus chrysippus*). *D. chrysippus* is a medium-sized butterfly with a forewing span of about 5.6 cm (56 mm). The thorax is black with many white spots and is about 0.9 cm (9 mm). The wings are orange and the top surface is brighter and richer than the lower surface. The apical half of the forewing is black with a white stripe. There are three black dots inside the centre of the hind wing. The wings have black edges and are bordered with semi-circular white spots, as shown in Fig. 8. This species has a sexual dimorphism, as adult males have huge fragrance glands on their hindwings but females do not have such glands.

Habitat. This species of butterfly is widely distributed, making its home in various habitats such as gardens, open fields and even urban areas.

Morphological characteristics. Some morphological characteristics used in the study of Plain tiger butterfly are as follows:

***Antennae*.** Antennae are used to detect smells. They are segmented. Butterfly has two antennae on their heads, as shown in Fig. 5. The antennae of a plain tiger butterfly are about 2 cm (20mm) in width and 1.3 cm (13mm) in length.

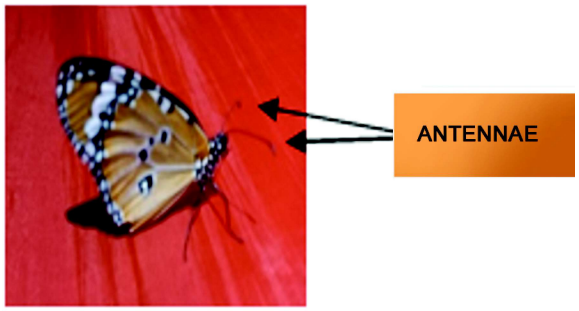


Fig. 5. The antennae of plain tiger butterfly.

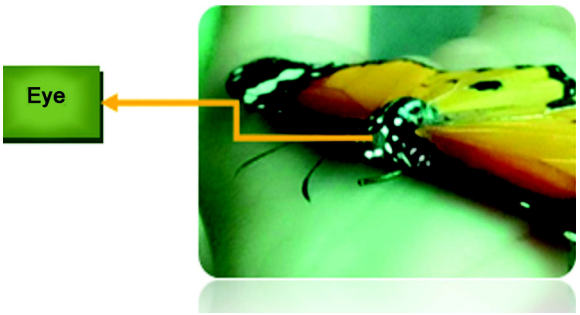


Fig. 6. The compound eye of plain tiger butterfly.

Eyes. Compound eyes are used to detect colors. A plain tiger butterfly has two compound eyes, shown in Fig. 6.

Proboscis. Proboscis is a long, straw-like tube for drinking nectar, as shown in Fig. 7.

Veins. Long scale-like structures on wings are called veins. The veins are white small tubes on plain tiger butterfly wings, as shown in Fig. 8.

Wings. Wings are attached to the thorax and have muscles to move. The forewings are the upper part of the wings of a butterfly. Hindwings are the lower part of the wings of a butterfly. Wings help with flying and make it vivid. Wing scales are overlap each other to form different patterns. The wings are movable. When a butterfly is in the resting stage, its wings are usually raised vertically, as shown in Fig. 9. They can spread horizontally and are sometimes brought back to cover a large portion of their hindwings. The wingspan of the plain tiger butterfly is about 7.4-8 cm (74-80 mm).

Host plant. The plants on which butterflies lay eggs and where the caterpillar grows are called host plants, as shown in Fig. 11. Each butterfly has its own specific host plant, which gives clues for their identification. The caterpillar host plants for the plain tiger butterfly are *Calotropis gigantea*, commonly known as Giant Milkweed (Aak); *Asclepias currassavica*, commonly known as blood flower and Mexican butterfly weed (shehzadi) as shown in Fig. 10.

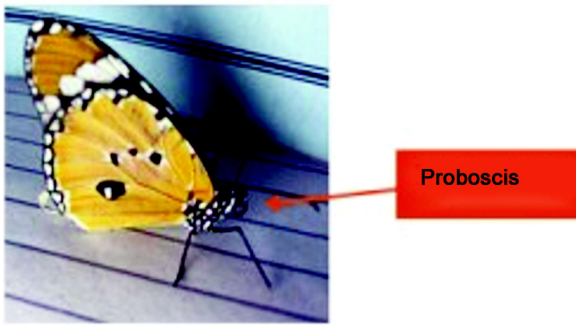


Fig. 7. Proboscis of plain tiger butterfly.

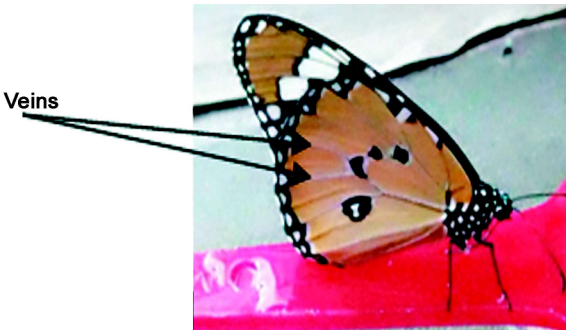


Fig. 8. The veins of plain tiger butterfly.

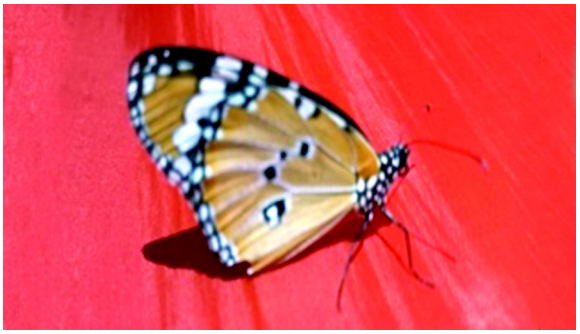


Fig. 9. The resting state of a plain tiger butterfly as wings is vertically upward.

Nectar. A solution of sugar and various other compounds that functions as a reward to promote insect pollination, especially by butterflies, is located on a flower's petals, anthers, stamens, sepals, pistils, styles, ovary and other parts. *D. chrysippus* mostly feeds on the nectar of flowers. It also likes the watermelon and the honey solution as shown in Fig. 12. A honey solution is made by mixing a small amount of honey with water.

Waste. The caterpillar excreted lots of solid waste as it eats lots of solid food as shown in Fig. 13. This waste could be used as bio-fertilizer.

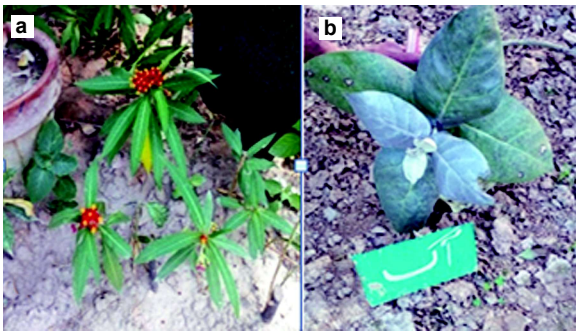


Fig. 10. The host plant of plain tiger butterfly (**a**) *Asclepias currassavica* (**b**) *Calotropisgigantea.*

Fig. 11. The plain tiger butterfly host plant (*Asclepias currassavica*) on which it lays egg.

Fig. 12. The butterfly food (**a**) butterfly feed on watermelon (**b**) butterfly drink honey solution.

Fig. 13. The solid waste excreted by a plain tiger caterpillar.

Locomotion. A caterpillar used its thoracic legs, abdominal prolegs and anal leg for locomotion, as shown in Fig. 14.

Breed. The male plain tiger butterfly used alkaloids to synthesize pheromones which are stored in hair pencils

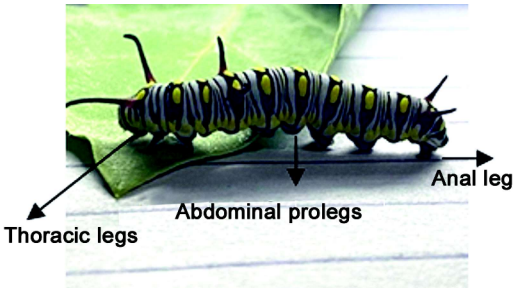


Fig. 14. The thoracic, abdominal and anal legs of a plain tiger caterpillar.

encased in alar organs which are specialized scales on the hind wing. Hair pencils are fanned out during courtship to release these pheromones and this appears to be essential for attracting females. Mating occurs preferentially between butterflies of the same subspecies, so colouration is probably also an important signal in the mating process. For mating, the male plain tiger butterfly joined its abdomen to the abdomen of the female plain tiger butterfly as shown in Fig. 15.

Life cycle of plain tiger butterfly and bio-entrepreneurship. Metamorphosis is a process in which an immature butterfly transforms from one stage to another. The developmental stages of a butterfly include egg, larva, pupa and adult as shown in Fig. 16. The life cycle of the plain tiger butterfly (*Danaus chrysippus*) was truly fascinating. From its humble beginnings as an egg to its stunning metamorphosis into a beautiful adult butterfly, every stage offered valuable lessons for bio-entrepreneurs seeking inspiration. The female butterfly lays its eggs on the food plant needed for the caterpillar which emerges from the egg and immediately starts molting. As it grows, it molts. After molting, the caterpillar transforms into a pupa. Then it transforms into a

Fig. 15. (**a**) a place where plain tiger (*D. chrysippus*) butterfly breed (**b**) show breeding process.

Fig. 16. The life cycle of plain tiger butterfly on a small scale (*D. chrysippus*).

butterfly. When the butterfly emerges, it dries itself and is ready to fly away.

We observed the plain tiger butterfly's life cycle on a small scale. The life cycle of the plain tiger butterfly went through four stages and the details are given below:

Eggs stage. The female's plain tigers laid a single egg on the underside of leaves of the caterpillar host plant. At the beginning of laying eggs, the eggs were white but gradually they turned creamy white or yellow with the passage of time. The eggs were dome shaped and longitudinally raised, as shown in Fig. 17. The eggs measured 0.09 cm (0.9 mm) in length and 0.08cm (0.8 mm) in breadth. Eggs hatched within 3 days depending on the temperature. After hatching, the newly hatched caterpillar consumed its own egg shell. The egg stage represented the foundation of a venture, emphasizing the importance of a solid base. Just like the tiny egg holds the potential for growth, entrepreneurs should lay the groundwork for their business ideas, establishing a strong foundation to support future growth.

Caterpillar stage. Our study revealed that plain tiger caterpillars pass through five caterpillar instar stages in an average of 9-10 days. They ate milkweed leaves and grew bigger, as shown in Fig. 19. They shed their skin five times. This stage highlighted the need for continuous learning and adaptation. As bio-entrepreneurs, we should continually acquire knowledge, refine our skills and adapt to changing circumstances. The caterpillar stages are reported in Table 1.

This table reported the complete observation of plain tiger caterpillar stage. We observed that the first instar

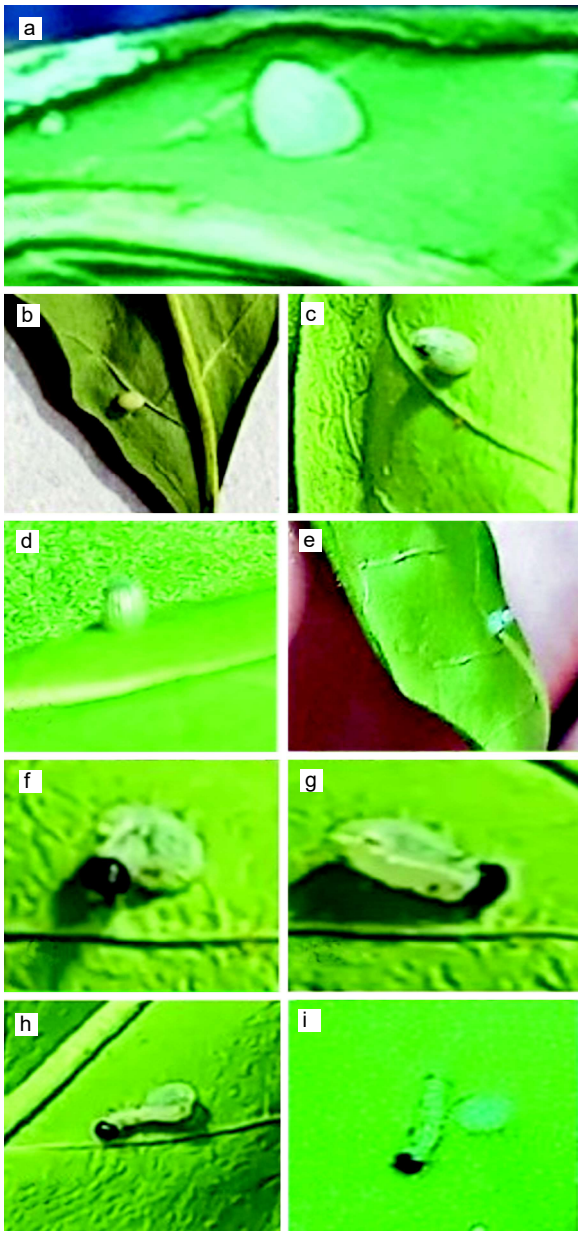


Fig. 17. The egg stage of the plain tiger butterfly (*D. chrysippus*) (**a**) the egg was dome shaped and longitudinal raised, (**b**) the egg turns into yellow colour, (**c**) front view of the egg, (**d**) side view of the egg, (**e**) the egg ready to hatch, (**f**) the egg began to hatch, (**g**) the newly caterpillar hatched, (**h**) the newly caterpillar start moving and (**i**) the caterpillar completely hatched.

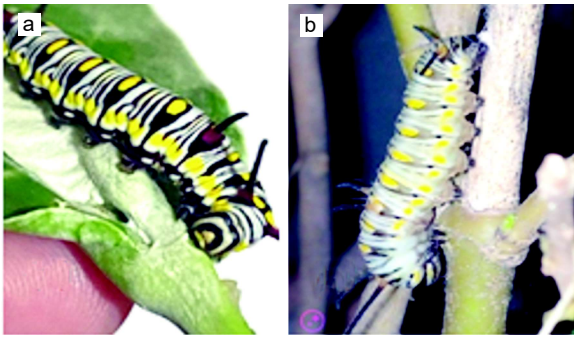


Fig. 18. The difference (**a**) the mature caterpillar of plain tiger butterfly (**b**) pre pupal stage of *D. chrysippus*.

Fig. 19. Different instars of the plain tiger caterpillar (*D. chrysippus*) (**a**) first instar, (**b**) second instar, (**c**) third instar, (**d**) forth instar, (**e**) fifth instar.

remained for three days with the length of 0.7cm (7 mm), second instar remained for two days with the length of 1.3 cm (13 mm), third instar remained for one day with the length of 2.2 cm (22 mm), forth instar remained for one day with the length of 3.2 cm (32 mm) and fifth instar remained for two days with the length of 3.6 cm (36 mm). When it started to form pre pupa its length was reduced to 2.2 cm (22 mm).

***Pupa stage*:** When the pre-pupa formed, it lost a small amount of body mass, as shown in Fig. 20. The pre-pupal stage last for one day, depending on the

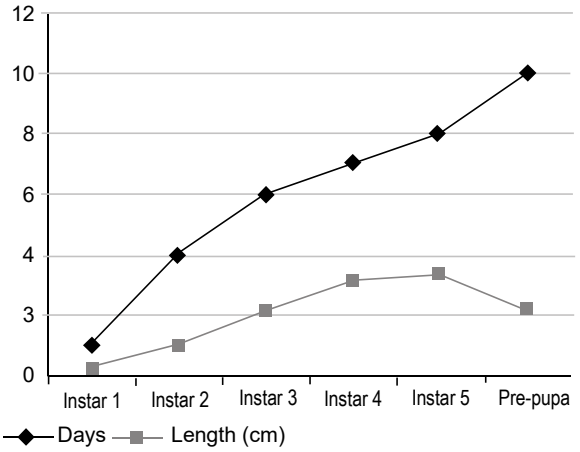


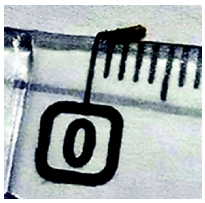
Fig. 20. Line graph represents spending days and length measurements of plain tiger butterfly (*Danaus chrysippus)* instar stages and pre-pupal stage (**a**) First instar grew for three days, expanding to a length of 0.3 cm (3 mm), (**b**) Second instar grew for two days, expending to a length of 1.1cm (11 mm), (**c**) The length of third instar was 2.2 cm (22 mm) and grew for one day, (**d**) Forth instar grew for one day with the length of 3.2 cm (32 mm), (**e**) Fifth instar achieved a final length of 3.4 cm (34 mm) and last for two days.When pupa became pre pupa its length was reduced to 2.2 cm (22 mm).

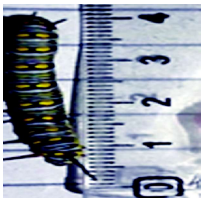
temperature. The pupal stage last around six to nine days, depending on the temperature. We observed that most pupae formed at night. The pupa's length was 1.8 cm (18 mm), while its breadth was 0.9 cm (9 mm). Plain tiger pupa day-by-day analysis was reported in Table 2. The pupa's body reorganized into the intricate butterfly form, demonstrating the power of reinvention. Bio-entrepreneurs should embrace change and view it as an opportunity for growth and transformation. This stage particularly is relevant for bio-entrepreneurs, who want to embrace change and adapted to thrive in a dynamic business landscape.

This table provided the day by day analysis of plain tiger pupa. The pupa (A) and (B) remained for 6 days while the pupa (C) remained for 9 days.

***Adult stage*.** The plain tiger butterfly egg completely transformed into an adult plain tiger butterfly, as shown in Fig. 22. An adult plain tiger butterfly had a head,

Table 1. Plain tiger caterpillar reading

Day	Length	Picture	Instar stage	Spending days
1	0.3 cm		First instar	3 days
2	0.5 cm			
3	0.7 cm			
4	1.1 cm		Second instar	2 days
5	1.3 cm			
6	2.2 cm		Third instar	1 day
7	3.2 cm		Forth instar	1 day

8	3.4 cm		Fifth instar	2 day
9	3.6 cm			
10	2.2 cm		Pre pupa	1 day

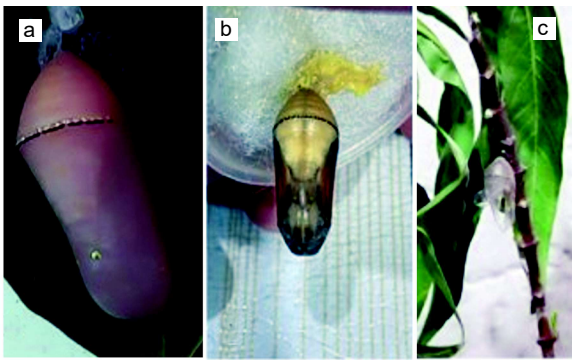


Fig. 21. The pupa of plain tiger butterfly (*D. chrysippus*) (**a**) The newly immature pupa (**b**) The mature pupa (**c**) The butterfly left pupa shell after emergence.

thorax, abdomen, six legs, four wings (two hind wings and two forewings), two antennae, two compound eyes, and a proboscis. The wingspan range was about 5.6 cm (50 mm). The head was about 0.3 cm (30 mm). The antennae were 1.3 cm (13 mm) long and 2 cm (20 mm) wide. The thorax was about 0.9 cm (9 mm) long. The abdomen was about 1.7 cm (17 mm) long. We recorded all readings of the plain tiger butterfly in Table 3. Some newly born butterflies were damaged because of less

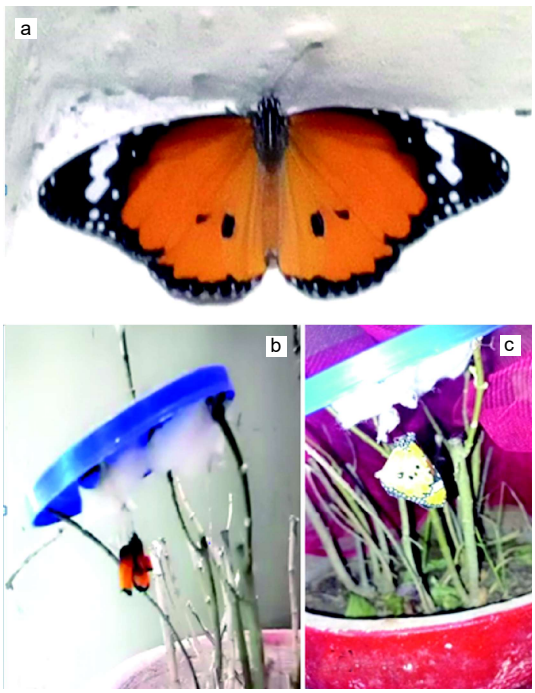


Fig. 22. The newly born plain tiger butterfly and emergence of plain tiger butterfly at home (*D. chrysippus*) (**a**) the newly hatched plain tiger butterfly (**b**) the butterfly emerged from pupa (**c**) the butterfly started to dry its wings.

Table 2. Plain tiger pupa day by day analysis

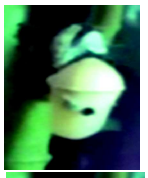
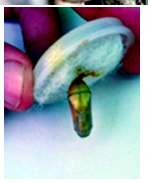
Day	Pupa (a) pictures	Pupa (b) pictures	Pupa (c) pictures	Observation
1				First day, pupa (a), (b) and(c) were pale yellow and had yellow vertical dots.
2				Second day, pupa (a), (b) and (c) were pale pinkish yellow.
3				Third day, pupa (a), (b) and (c) appearance were same as second day.
4				Fourth day, organs developed in the pupa (a) and (b). The pupa (c) appearance remained the same as the second day.
5				Fifth day, the pupa (a)'s and (b)'s organs colour was modified and darker. The pupa (c) appearance remained the same as the second day.
6				Sixth day, the pupa (a) and (b) were completely matured, the butterflies from , the pupa (a) and (b) were ready for the emergence. The pupa (c) appearance remained the same as the second day.
7				Seventh day, the organs were developed in the pupa (c).
8				Eighth day, the pupa (c), the organ's colour was modified but lighter than pupa (a) and (b).
9				Ninth day, thepupa (c) was fully matured and ready to emerge.

Table 3. The plain tiger adult measurements

Adult plain tiger butterfly body parts	Plain tiger (a) (cm)	Plain tiger (b) (cm)	Plain tiger (c) (cm)	Plain tiger (d) (cm)	Mean (cm)
Head	0.3	0.3	0.2	0.3	0.3
Thorax	1	0.9	0.7	0.9	0.9
Abdomen	1.2	1.1	1	1.7	1.3
Forewing span	2.7s (6.4d)	2.9s (5.9d)	3.2s (6.3d)	3.7s (7.4d)	3.1s (5.6d)
Hindwing span	2.4s (5.0d)	2.1s (5.5d)	2.6s (5.4d)	2.9s (6.0d)	2.5s (5.5d)
Body length	4.9	5.2	5.5	5.8	5.4
Antennae	1.4	1.4	1.2	2	1.5

s means single wing span; b d means double wing span.

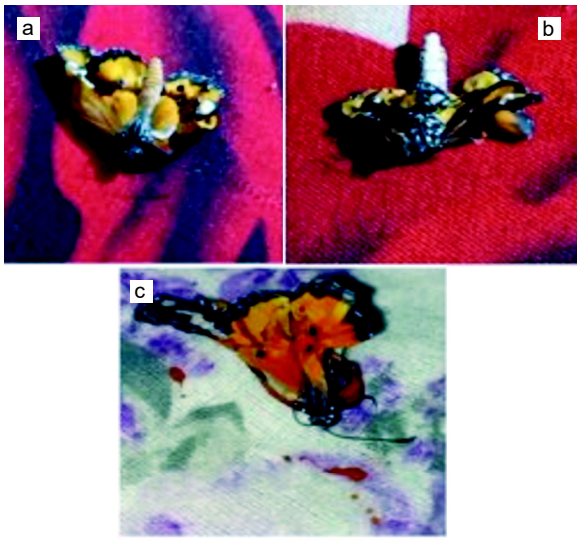


Fig. 23. The damaged plain tiger butterfly (**a**) dorsal view (**b**) ventral view (**c**) the damaged butterfly died.

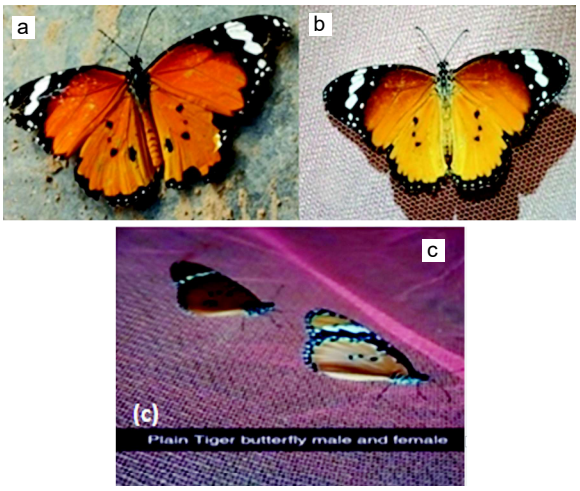


Fig. 24. Male and female difference (**a**) the male plain tiger (*D. chrysippus*), (**b**) the female plain tiger (*D. chrysippus*) (**c**) the side view of the male and the female plain tiger butterfly.

care given to their pupa, as shown in Fig. 23. The butterfly's emergence symbolized the realization of potential and the ability to spread one's wings. For bio-entrepreneurs, this stage represented the fulfilment of their dreams and the recognition of their hard work. Like the butterfly, they can now fly confidently, utilizing their talents and seizing opportunities.

***Damaged butterfly*.** Some butterflies emerged wrongly, as their abdomens emerged first. Some emerged with damaged wings. The damaged butterflies died earlier.

***Male and female difference*.** Male and female species of *D. chrysippus* look similar and are also similar in size. Males have additional black spots on their hind wings while females do not, as shown in Fig. 24. This spot in male species helps males for mating purposes.

We uncovered the secrets of success hidden within the life of this captivating butterfly. The plain tiger butterfly's life cycle and behaviour can provide valuable insights for bio-entrepreneurs seeking success in the fast-paced business world, offering practical strategies to guide their pursuit of success.

Bio-entrepreneurs should embrace their new identity and passion for creating, similar to the plain tiger butterfly. Utilizing the internet like Etsy's advertising platforms and building a strong online presence can expand their reach. Butterfly farming can be rewarding, promoting conservation and preserving natural habitats. It can also be used for special occasions and educational purposes.

Bio-entrepreneurship strategies include management, capital and technology. Biotechnology utilized more resources and capital, while biology used less due to scientific methods and natural resources, offering opportunities for small-scale growth.

Bio-entrepreneurship was established in many Asian countries and infrastructure is being developed. Singapore, Taiwan, Korea and Australia are leading the way (Tang *et al*., 2003). South Africa developed a bio-entrepreneurship training program at cape biotech, bridging biotechnology science and commercialization (Uctu and Jafta, 2014). Bio-entrepreneurship challenges are influenced by biotechnology sector characteristics, business conditions and social environment. The traits of successful bio-entrepreneurs were compared in the UK, France and Germany, proposing a competency model (Gurau, 2006). Meyers and Hurley reviewed US bio-entrepreneurship education programs and identify critical success factors (Meyers and Hurley, 2008). Shahid and Azim reviewed highlighted factors impacting bio-entrepreneurship opportunities in developing economies (Shahid and Azim, 2019).

In the Islamic Republic of Pakistan, the business sector accounts for 80% of non-farm employment, 40% of GDP and 25% of exports (Khan, 2016). Butterfly farming is a valuable source of income for rural areas. It requires less effort and land compared to other farming industries, with minimal costs to the producers. Female bio entrepreneurs would benefit most from butterfly farming. Women in rural Pakistan, who traditionally work at home, can easily rear butterflies. It does not require special education (Rafi *et al*., 2003). This provides an alternative livelihood and increases purchasing power, leading to increased production in other sectors of the economy.

For many years, the butterfly trade, which originated mostly in the tropics, was a significant industry. The trade of "butterfly wing picture frames" in Africa produced $500,000 in revenue. Professional collectors sold specimens to wealthy patrons or collectors in the tropics who had historically made good livings with a particular fascination for butterflies from southeast asia and the western pacific region. The Indo-pacific region had a major hub for collectors of rare, large and spectacular butterflies with highly diverse faunas (New, 1997).

Butterfly farming was determined to be the primary source of revenue. In Tanzania butterfly farming projects had established such as the Zanzibar Butterfly Centre and the Amani Butterfly Project. These projects raised local butterfly larvae and sold them in Europe and the United States. Annual sales grew from $20,000 in 2004 to $89,000 in 2009. Families and the United States. Annual sales grew from $20,000 in 2004 to $89,000 in 2009. Families in Msasa Kwezitu earned 20% income from butterfly forming (Anderson and Saidi, 2011) Pupae exported from Costa Rica have averaged over USD 700,000 annually since 2000 (Rios, 2002).

In southern Mexico's live butterfly traded as a bio-entrepreneurship. The butterfly products from butterfly houses of southern Mexico sold for release at social events, showcasing various butterfly species. Over 85% of these species were from the Nymphalidae family, making them attractive to visitors. Producers sold directly to consumers at prices ranging from $0.25 to $4.37 in US dollars. Butterfly houses attracted visitors of all ages and financial levels because of low ticket prices which seldom surpass $2.50. Fifteen butterfly species bred commercially in the Yucatan Peninsula (Gutiérrez *et al*., 2023). Butterfly kits sold to schools, with caterpillars, eggs and artificial meals, allowing youngsters to see meta morphosis and enjoy the butterfly's freedom (Boppre and Van-Wright, 2012).

Currently, there is a great need to explore different ways in bio-entrepreneurship to raise Pakistan's economy, as there is no such work done in Pakistan in the field of bio-entrepreneurship. In the present study, our experiment as bio entrepreneurship on a small scale was successfully commenced. We explored various ways to develop a successful venture in Pakistan in the field of biology. This study provided some information about butterflies and the process of beginning a butterfly farm. We suggest growing Lepidopterarium on a large scale in future and we provided a sketch of the management and the capital needed for large scale Lepidopterarium as shown in Tables 4 and 5.

The process of reproduction for most plants relies on the presence of pollinators such as bees and butterflies. The production value of crops that depend on pollination in Pakistan has been quantified at an impressive 1.59 billion US dollars (Irshad and Stephen, 2014).

Society requires a serene retreat to rejuvenate their minds and butterflies provide a delightful means to fulfil this need. As a bio-entrepreneur butterfly Lapidopterarium in tourist areas attracts visitors with additional services like restaurants, coffee shops and souvenir shops where they can sell butterfly-related products and generate most of their income.

Our study focused on growing a Lepidopterarium and ways to utilize it as a bio-entrepreneurship, which was a first-time attempt in Pakistan. During the study, we successfully raised six butterflies without any loss. Additionally, we created a display box using these preserved specimens.

Table 4. Butterfly business model requirements

Area	On large scale 9.3m^2 (30 feet)	On small scale 3.27m^2 (10 feet)
Materials	10 to 15 plain tiger butterflies, 3 to 5 plain tiger butterfly host plants (milkweed), 4 to 5 nectar flowering plants, 2 measuring scales, a camera, a shelter (net), 5 to 8 plastic cups for caterpillar and eggs, 3 to 5 pupa kits. Air conditioners and honey solution as a nectar if needed.	7 to 9 plain tiger butterflies, 2 plain tiger butterfly host plants (milkweed), 2 nectar flowering plants, a measuring scale, a camera, a shelter (net), 3 to 5 plastic cups for caterpillar and eggs, 2 pupa kits. Air conditioners and honey solution as a nectar if needed.
Management	2 to 4 person require for management	1 to 2 person require for management

Table 5. Capital for butterfly business on a small scale and large scale

	On large scale	On small scale
Materials	$ 450	$17.17 as some material was already available.
Management	$140 to $280 for 2 to 4 persons	$ 0 as we were the managers for this project.
Shop décor and interior decoration models	$2,000	$ 5.23
Area rent	$ 3,500	$0
Software expenses	$ 225	$0
Business cards	$50	$0
Business signage	$2,486	$0
Website cost	$215	$0
Google ads	$300	$0
Package designed	$ 3,000	$0
Total	$12,866 to 12,506	22.40

Conclusion

This study was successfully conducted Lepidopterarium on a small scale at virtual university, Punjab, Pakistan from May 2022 to July 2023, approximately 9 plain tiger butterfly started Lepidopterarium on a small scale and 6 plain tiger butterfly went through metamorphosis. Our capital to produce a small venture was about $22.40.

The current study is Pakistan's first representation of bio-entrepreneurship, specifically using the butterfly as a model. In this study were examined the three pillars of entrepreneurship, namely management, capital and technology by building a small-scale plain tiger Lepidopterarium. This study explored various ways to become a bio-entrepreneur and provided a sketch to grow bio-entrepreneurship of Lepidopterarium on large scale as reported in Table 5.

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Conflict of Interest. The authors declare that they have no conflict of interest.

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