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Distribution and biology of the yellow-spotted longicorn beetle *Psacothea hilaris hilaris* (Pascoe) in Italy

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The Asiatic yellow-spotted longicorn beetle, *Psacothea hilaris hilaris*, was found for the first time in Northern Italy in 2005. As the xylophagous insect is considered one of the most important pests of *Morus* spp. and *Ficus carica* in its countries of origin, a multi-year study was carried out to determine the spread of the pest in Northern Italy, to evaluate its establishment potential and to improve knowledge on its biology in the new habitat. The survey confirmed that *P. hilaris hilaris* has established in Italy and has colonized an area of about 60 km^2. The species overwinters as eggs or larvae. Adults are present from June to October. Damage has been recorded mostly on *Ficus carica* plants, and very rarely on *Morus alba*. Both young and older plants in healthy and stressed phytosanitary condition can be attacked by the pest. Severely attacked plants become weakened and ~~are~~ eventually ~~killed~~.

Introduction

Psacothea hilaris (Pascoe) (Coleoptera Cerambycidae Lamiinae Lamiini), commonly known as the yellow spotted longicorn beetle, is native to the East Asia where it is widely distributed. The species *Psacothea hilaris* includes 13 subspecies distinguishable by their morphology (Kusama & Tatakuwa, 1984). The subspecies present in Europe is *Psacothea hilaris hilaris* which occurs in China and Japan.

In its area of origin *P. hilaris* is a destructive and economically important pest of plants belonging to the Moraceae family, including fig trees (*Ficus carica*) and mulberry trees (*Morus* spp.). In Japan *P. hilaris* is a serious pest of sericulture, as the larvae bore tunnels in the trunks and the adults feed on the leaves of mulberry trees, which are the food source of *Bombyx mori*. In Europe, where sericulture has nearly disappeared, the insect can attack *Morus* trees grown for ornamental purposes. As the production of figs is important around the Mediterranean Basin, and many fig trees are grown in private gardens, the establishment of the pest in this area could become a threat for fig production.

Psacothea hilaris hilaris adults are easily recognizable: the tegument is black and it is covered by a green-grayish pubescence with yellow spots on the elytra and the abdomen, and yellow stripes on the *pronotum* (Fig. 1). Variation in the body size of *P. hilaris hilaris* is conspicuous, especially in males: the body length (from the head to the tip of elytra) varies from 13 to 30 mm in males and from 15 to 31 mm in females (Iba, 1993; Fukaya, 2004). Adults are characterized by long antennae whose length is longer than twice the length of the body in males and longer than 1.5 the length of the body in females.

The larvae are xylophagous and bore tunnels in the trunks and branches of different diameter under the bark (Hanks, 1999). After a first period of feeding under the bark, the larvae tunnel into the xylem of host trees. This results in considerable damage to the tree which is progressively weakened. The adults feed on the leaves and on the tender bark of the smaller branches (Jucker *et al.*, 2006). Studies on the biology in the countries of origin indicated that *P. hilaris hilaris* is generally univoltine, although the species can complete its life cycle in two years, or can have two generations per year, depending on the time oviposition occurs (Watari *et al.*, 2002). Two different ecotypes of this subspecies are described in Japan: Ecotype E (East Japan type) which does not undergo winter larval diapause and it is thus distinguishable from the ecotype W (West Japan type), which does (Iba *et al.*, 1976; Iba, 1980; Makihara, 1986; Sakakibara & Kawakami, 1992; Shintani & Ishikawa, 1999). The two ecotypes can also be distinguished by the stripe pattern on the pronotum (broken in the Western ecotype, continuous in the Eastern) (Iba, 1980). Depending on the ecotype, adults' emergence peaks in different period over the year. The W-type has its main emergence peak in early summer and a smaller one in autumn, while the E-type has an increase in the population in autumn, but does not form a sharp emergence peak (Iba *et al.*, 1976; Sakakibara & Kawakami, 1992).

The beetle has been discovered several times in North America and Canada in warehouses, on wood and wooden spools imported from Asia. The species was also intercepted in the UK in 1997 but it did not establish. Subsequently in 2008 in the United Kingdom one live adult beetle was detected in a public garden in Derbyshire (East Midlands) (EPPO, 2008/201), but no information is available about its establishment in the country (~~http://www.fera.defra.gov.uk~~). In Italy *P. hilaris hilaris* was first recorded in Lombardy Region

COLOR

Fig. 1 Adult of *P. hilaris hilaris.*

(Northern Italy) in September 2005 when two dead specimens (one male and one female) were collected near a wood warehouse, in the municipality of Almenno San Salvatore (Bergamo province) (45°45′28.6″ N; 9°35′53.18″ E). The same year, in October, another adult was captured in Asso (Como province) (45°51′36.96″N; 9°16′16.71″E), about 30 km away from the first point of detection, and brought to DeFENS - University of Milan. In both cases no infested plant was detected on the site (Jucker *et al.*, 2006). *P. hilaris hilaris* was considered to have probably been introduced into the area via firewood or import of fig trees. However the exact point of entry and origin is not known. In 2008 *P. hilaris* was added to the EPPO Alert List. In 2012 the species was deleted from the list because it has been included for more than 3 years and during this period no particular international action was requested by the EPPO member countries.

As the species was detected again in 2007 in Anzano del Parco (Como province) (45°46′08.09″N; 9°12′12.09″E), a municipality located about 10 km from Asso, and numerous live insects and attacked fig plants were found, a multiyear study started. This paper reports the information acquired on the establishment potential of the new pest in Northern Italy and its spread. Data on the bio-ethology and the potential damage that could be caused by this wood borer in Italy were also obtained.

Materials and methods

Geographic distribution of *Psacothea hilaris hilaris* in Italy

The study area is in the south of Como lake, one of the largest hydrographic basins in Northern Italy. This is a highly populated area with fig trees cultivated in many private gardens and plants also growing as ruderal species in undisturbed areas. As this region was one of the most important for sericulture at the beginning of the twentieth century, *Morus alba* plants are still present as ornamentals, planted in parks and along streets. The climate in the area is subcontinental (Pinna, 1978), and in proximity of the lake the winter is milder.

The survey started in Anzano del Parco (CO) where the first live adults of *P. hilaris hilaris* and symptomatic plants were detected. The localities were initially visited in 2008, to investigate whether the insect had established. The sites were checked yearly to evaluate the presence of the species and its distribution. Further sites were randomly chosen in the neighbourhood and in the nearby municipalities. Visual inspections were also carried out following recommendations from people living in the infested area. The position of each site was georegistered with eTrex VISTA HCx GARMIN. The methods used to detect the insect and/or the symptoms of its presence were dependent on the season and, consequently, the stages of the insect present.

Bio-ethology and dangerousness

To acquire data on the bio-ethology of the pest in the new habitat, from spring 2010 to autumn 2012 two sites (45°49′ 40.06″N, 9°13′07.44″E; 45°46′09.98″ N, 9°11′52.86″E) with about 30 infested plants were chosen.

Surveys were carried out throughout the year and the presence of different instars was documented (eggs, preimaginal instars, adults). Presence of adults was ascertained by visual inspection in the canopy. When possible the specimens were captured, prepared and stored in entomological boxes. For the observation of the preimaginal stages, the bark was removed when sawdust was observed on the outside of the trunks or branches. In addition some branches were cut from infested plants in different localities, transferred to the laboratory of the University of Milan and kept at room temperature to allow adult to emerge and to confirm insect species and evaluate its sex ratio. Emergence holes in dead plants were counted and their depth into the wood evaluated.

Results

Geographic distribution of *Psacothea hilaris hilaris* in Italy

The species was observed in 29 sites within 19 municipalities (Table 1). The latitude of these sites ranged from 6

COLOR

Fig. 2 Distribution map of *P. hilaris hilaris* in Italy (~~in green;~~ point of first detection in 2005; ~~in yellow;~~ area of spreading in 2012).

45°52′48″N to 45°45′10″N and the longitude from 9°18′11″ E and 9°05′41″E, with an altitudinal range from 227 m to 626 m above sea level. Over seven years *P. hilaris hilaris* spread to an area of about 60 km^2. Infested areas were contiguous with the exception of the finding in Como city (Fig. 2). Establishing the precise distribution of the insect is difficult as the fig plants are mostly found inside private gardens or in ruderal areas which can be difficult to access. In 8 of the 29 localities adults were collected but the host plants could not be localized. Although in Table 1 the year of detection was reported in different localities, the year is not always indicative of the arrival of the insect, which may have taken place some years before. In many cases the plants were already in a very poor condition at the first visit and covered with emergence holes. In some localities plants were removed immediately after the insect detection, in the subsequent year it was no longer possible to follow the infestation of *P. hilaris hilaris*.

Bioethology and dangerousness

The insect was principally detected in association with fig trees. There was only one site (45°49′40.06″N, 9°13′07.44″E) where mulberry trees were attacked.

Adults were observed from mid- June until the end of October. Adults did not show a peak of emergence, but emerged gradually during the observation period. They were observed both in the canopy and on the trunks, feeding on the tender bark, on foliage, shoots and occasionally on fig fruits (Figs 3a,b). Approximately 20–30 days after

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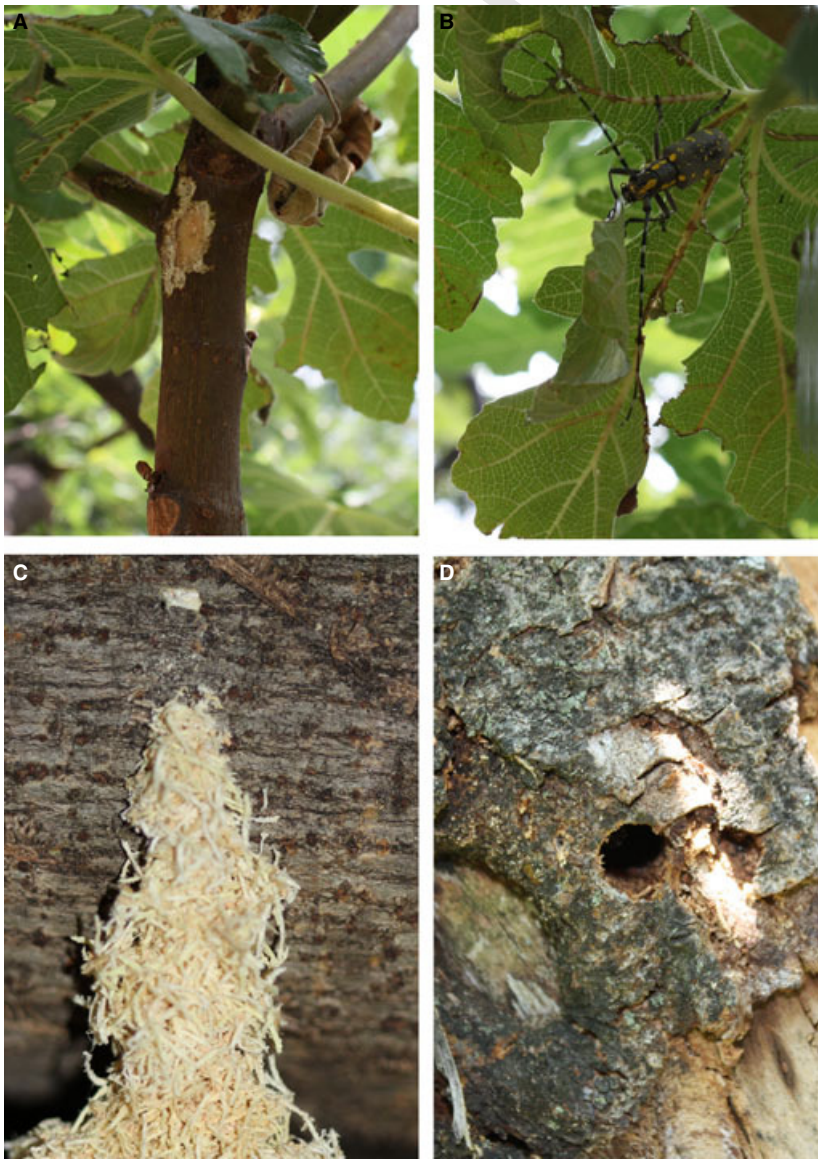

Fig. 3 Adult feeding (A, B); sawdust (C); exit hole (D).

emergence, females were observed laying eggs on trunks and branches. A few days after egg-laying a small amount of sawdust was visible outside the bark (Fig. 3c).

Winter surveys showed the simultaneous presence of eggs and larvae. Observations in spring in 2011 and 2012 established the capability of overwintering eggs to hatch and larvae to begin their activity under the bark. This information is in line with the results of Shitani and Ishikava (1999), that established that the minimum temperature at which the eggs can survive is −27°C while that of neonate larvae is −18°C. In the study area temperatures never reached these values as the lowest temperatures recorded in winter were −5.3°C and −11.5°C respectively in 2011 and 2012 (data provided by 'Servizio Meteorologico Regionale – ARPA Lombardia', www.arpalombardia.it).

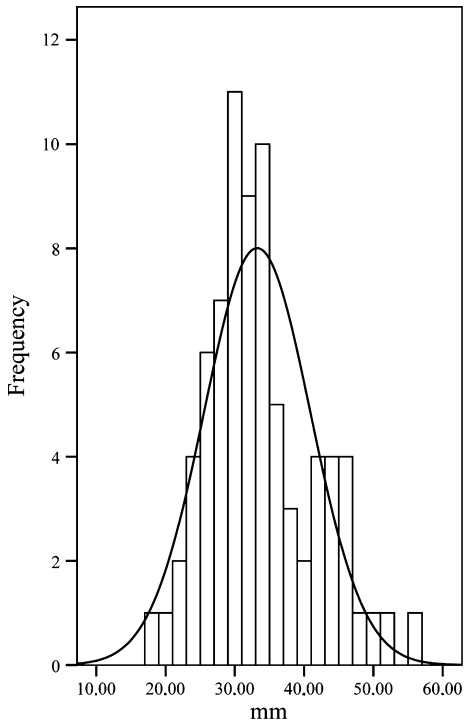

Fig. 4 Frequency histogram of gallery depth in fig plants.

During the surveys many subcortical larvae, with a maximum head capsule width of 3.5 mm (n = 58), were found. Then the larvae migrate into the xylem and develop until they reach a maximum head capsule width of 4.99 mm (n = 37) before pupation. The depth of the gallery into the trunk, calculated from emergence holes, varied from 18.0 mm to 55.0 mm with a mean value of 33.2 ± 7.7 mm (n = 77) and was not related to the diameter of the infested part of the plant (Fig. 4).

Adults emerged by chewing an exit hole through the bark (Fig. 3d). The emergence holes were observed mostly on trunks, on principal and secondary branches but also on exposed roots. The sex ratio obtained in a sample of 289 specimens was 0.89 females/males. In 4 sites many plants were observed to have died following infestation with *P. hilaris hilaris* (Fig. 5).

Two dead fig trees (girth at 1 m: 40 cm; 55 cm; height ground-first branches: 2.2 m; 2.3 m) detected respectively in 2010 and 2011, had nearly 250 emergence holes on the two plants. The variability of the dimension of the body of the adults was confirmed by the diameter of the circular exit holes which varied from 3.0 to 12.0 mm with a mean value of 7.86 ± 1.30 mm (n = 240) on fig trees (Fig. 6).

Fig. 5 Decaying fig plants.

Discussion

The survey confirmed that *P. hilaris hilaris* has established in Italy; it represents one of the numerous examples of recently introduced exotic species into the country which have been able to establish (Jucker & Lupi, 2011).

Until a few years ago, phytophagous pests caused little damage to fig plants in Italy. At present *F. carica* is threatened by two exotic pests: *P. hilaris hilaris* and *Aclees* sp. (Coleoptera Curculionidae) (Ciampolini *et al.*, 2005), causing serious damage and plant death. In 2012 another Lamiinae was detected in Central Italy, *Batocera rubus albofasciata* Degeer (http://www.ersa.fvg.it), but no information is currently available on its possible establishment.

Psacothea hilaris hilaris has spread over the last seven years, but it is still confined to a relatively small territory in the north of Italy. The species was able to survive and complete its development not only on healthy and vigorous trees, but also on stressed and weakened hosts. Insects can emerge from decaying or dry plants. Moreover, the yellow-spotted longicorn is able to develop on small branches removed from the plant of approximately 1 cm diameter. This increases the survival of the species and therefore control is more difficult. In the period of study, numerous fig plants attacked by the beetle were weakened and died. The above observations are in contrast with those reported by Hanks (1999) in his review on Cerambycid reproductive behavior which stated that *P. hilaris* is incapable of killing the host.

The information presented in this paper underlines the damage that *P. hilaris* may cause and hence the necessity to study the biology and proper control measures. The species, currently present only in a small area where fig is cultivated mostly in private gardens, could become invasive if it spreads to regions of Italy and of the Mediterranean Basin where *F. carica* orchards are economically important.

Acknowledgements

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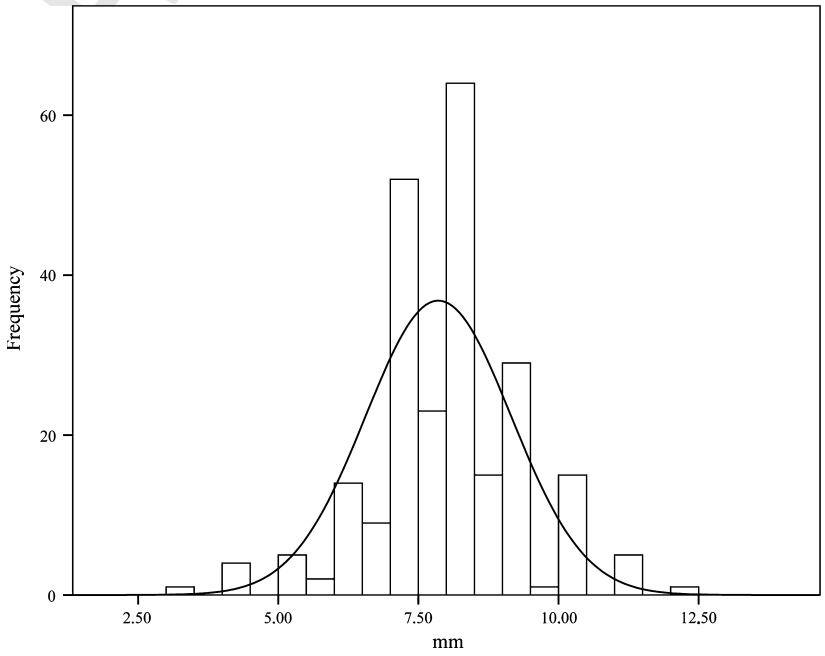

Fig. 6 Frequency histogram of exit holes diameter in fig plants.

and older plants in healthy and stressed phytosanitary condition can be attacked by the pest. Severely attacked plants become weakened and are eventually killed.

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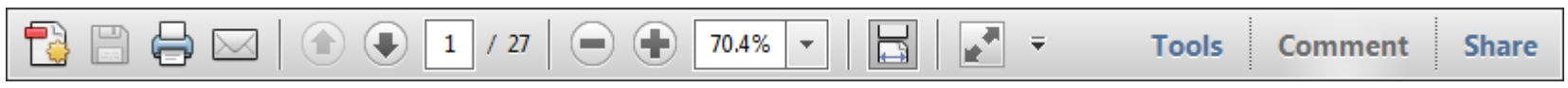

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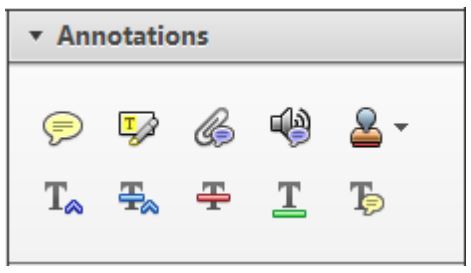

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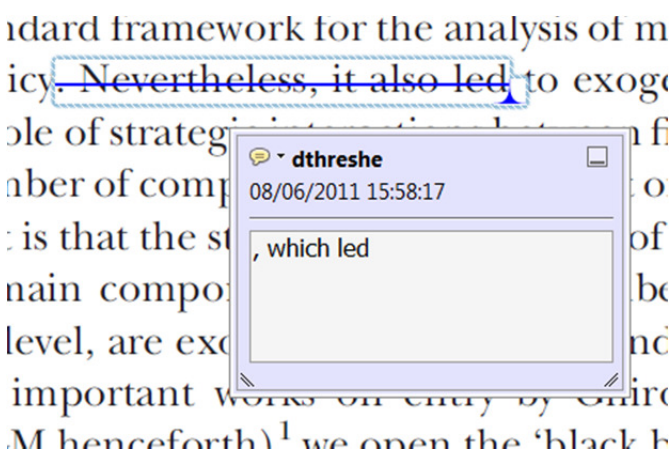

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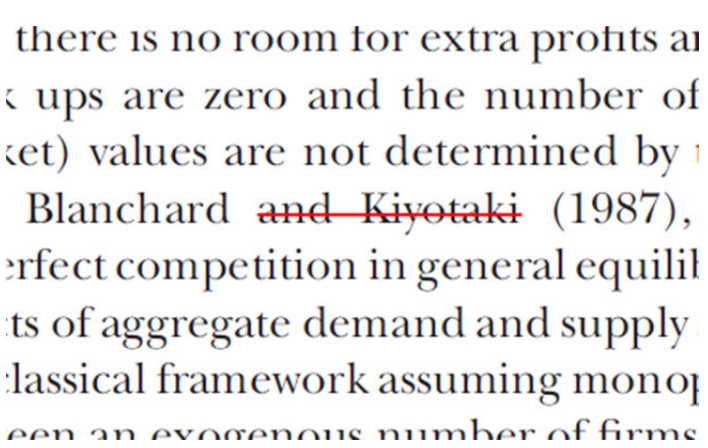

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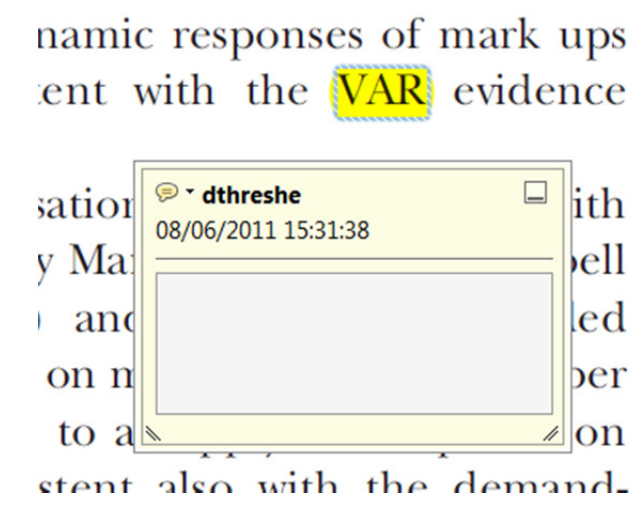

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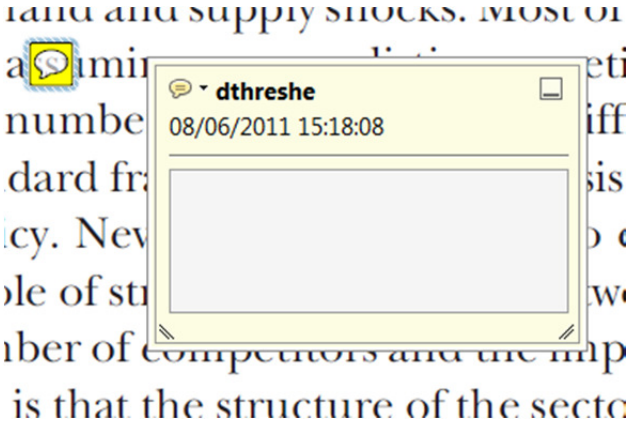

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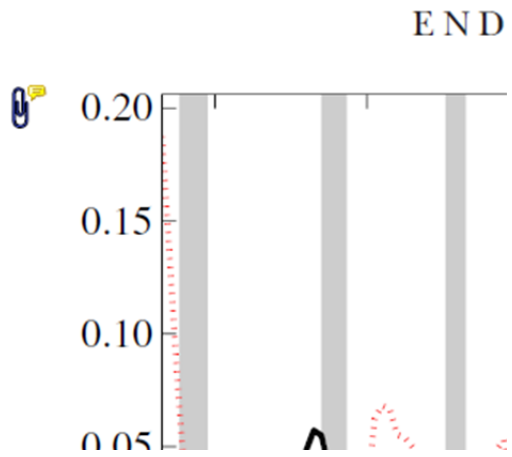

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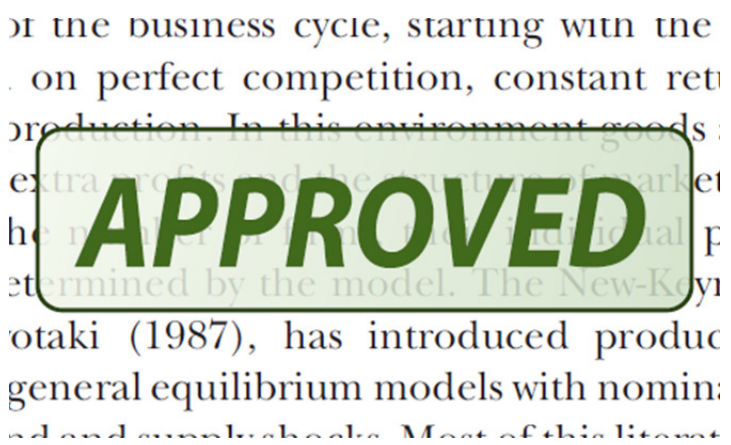
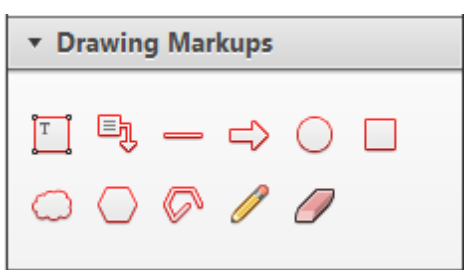
- Click on the proof where you'd like the stamp to appear. (Where a proof is to be approved as it is, this would normally be on the first page).



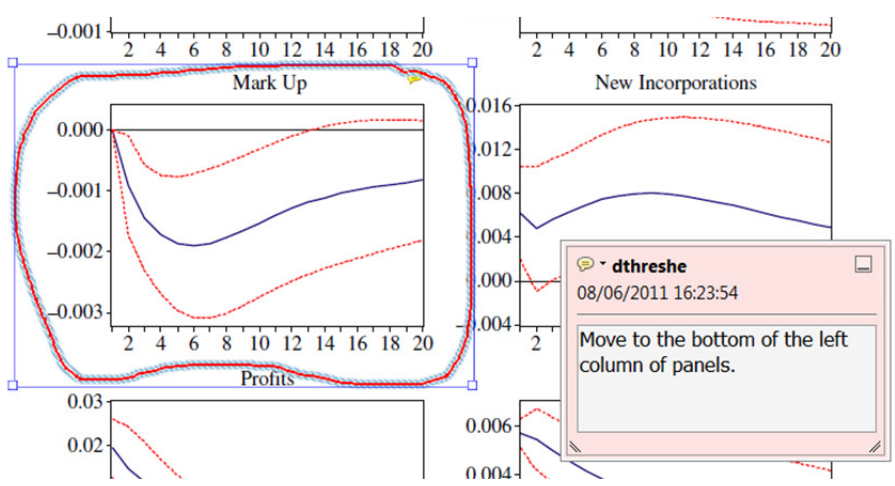


7. Drawing Markups Tools – for drawing shapes, lines and freeform annotations on proofs and commenting on these marks.

Allows shapes, lines and freeform annotations to be drawn on proofs and for comment to be made on these marks..

How to use it

- Click on one of the shapes in the Drawing Markups section.
- Click on the proof at the relevant point and draw the selected shape with the cursor.
- To add a comment to the drawn shape, move the cursor over the shape until an arrowhead appears.
- Double click on the shape and type any text in the red box that appears.



For further information on how to annotate proofs, click on the Help menu to reveal a list of further options: