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Ultrastructure Alterations in the Red Palm Weevil Antennal Sensilla Induced By Gamma Irradiation

Eman A. Mahmoud, Hussein F. Mohamed* and Samira E.M. El-Naggar
Biological Applications Department, Nuclear Research Center,
Atomic Energy Authority, Abo-Zaabal, Cairo,
Egypt

1. Introduction

Palm beetles (Coleoptera: Curculionidae) are harmful pests for cultivated palm – oil, date or coconut palms (Bedford, 1980, Giblin-Davis *et al,* 1996). The red palm weevil (RPW) *Rhynchophorous ferrugineus* (Oliv.) is the most important pest of the date palm in the Middle-East (Abraham & Pillai, 1998). The insect was discovered in Saudi Arabia in the mid-1980s (Gush, 1997 & Faleiro *et al*., 1999). Since then it has spread over most of the date palm areas (Bokhari & Abuzuhira 1992 & Vidyasagar *et al*., 2000), due to the transfer of infested offshoots and palm trees.

It was introduced accidentally into the Gulf states from Pakistan in 1985, from whence it spread throughout the Arabian Peninsula. It was first reported in Egypt in 1992. It infested the governorates Ismailia and Sharkia, an area with an estimated one million palm trees (Salama & Abdel Aziz, 2001). lthough they have been known as major pests for a long time, efficient and acceptable methods of controlling them are still lacking in many cases. In addition, the selection of plants for oviposition is determined by the physical nature of their surface and by chemical factors which are detected after contact (Fenomore, 1980, Chadha & Roome, 1980). As such, the identification of olfactory and contact chemoreceptors in insects has received the attention of many workers (Albert, 1980, Bland, 1984 & Salama *et al*., 1987).

Antennae in insect are organs of taste, smell and stimulation (Wiggles worth, 1972). Other authors (Stubbs, 1980, Nakamuta, 1985 & Obata, 1986) have suggested a possible role of sensory stimuli (olfactory, gustatory or mechanical) in prey, or mate detection. The antennae also play kinetic roles and normally keep the nervous system in a state of tone in which it responds to stimuli of all kinds. Antennae of insects vary greatly in length, overall size, size of the individual segments, segmentation, setation and other aspects with the structures being closely related to their function (Srivastava & Omkar , 2003). Notably, some authors studied the ultrastructurally effects of gamma rays on the features of normal antennal sensilla of *R. Ferrugineus* as Oland *et al*., (1988); El-kholy & Mikhaiel (2008) and El- Akhdar & Afia, 2009.

Despite the importance of sense organs on the antennae of red palm weevil (for oviposition, feeding and mating) there is little information about it. Therefore, the objective of current study is to describe the distribution, types of sensillae in *Rhynchophorus ferrugineus* using scanning electron microscopy, and estimate the effects of gamma radiation on them. This information may be useful for controlling the pests.

2. Materials and methods

2.1 Insect rearing technique

Red palm weevil, *R. ferruginous* adults were obtained from cocoons collected from infested date palm trees in the Salhia district (Sharkiya governorate, Egypt). A large number of cocoons were put into oblong opaque –white plastic boxes (21 x10.5x 7 cm in length, width and high respectively) covered with tight-fitting and perforated lids. Cocoons were kept in wet toweling until adult emergence.The newly emerged adults were sexually differentiated. Newly laid eggs from the adult culture were collected using a 0.2 mm brush and inserted into round plastic Petri dishes (50 mm diameter x 20 mm high) containing tissue paper soaket in Benzoate solution, which was renewed daily. The Petri dish had a screw cap and uniformly spaced perforations (2 mm diameter) around the surface of the box including lid and bottom.

The hatched larvae were maintained in plastic cups (250 ml capacity) containing 5g of artificial diet as described by Rahalkar *et al.,* (1985). The plastic cups were covered with muslin cloth and kept at controlled laboratory conditions (27°C and 85% RH). Daily inspection was carried out until eggs hatched and the larval and pupal stages were completed. After emergence, adult weevils were transferred into wire screen cages containing pieces of suger cane as food.

2.2 Irradiated treatments

Adults weevils, 2 weeks after emergence, irradiated with 15, 20 Gy of gamma radiation using gamma cell (^{60} Cobalt –Source), installed in the Middle Eastern Regional Radioisotope Center for the Arab Countries, Cairo, Egypt, with the dose rate of 1 Gy / 1.95 sec.

2.3 Examination with the scanning electron microscope (SEM)

unirradiated and the irradiated adult weevils were freeze by liquid nitrogen then dried in the chamber of the scanning electron –microscope, SEM (Jeol-JSM-5600 LV in SEM Unit, Central Laboratory for Elemental Analysis, Inshas, Egypt) in the low vacuum mode. Then the micrographs were taken, this technique called low vacuum scanning electron microscope freeze drying (L V-SEM)(Gasser *et al*.,2008) .This technique resulted in the presence of few small particles in white color represents ice during freeze drying technique of the specimens in low vacuum SEM on the micrographs

3. Results

The antenna of the red palm weevil measures about 0.9 cm in length (geniculate antenna). It arises from the elongated anta cava in front of the anterior margin of the compound eye and at the base of the rostrum. It consists of three segments, (scape, pedicel, and flagellum) differing in size and shape (Fig.1).

3.1 The scape

It is the longest segment; it measures more than one-third of the length of the antenna. Proximally, it has a hook fitting in the antennal groove, while distally it is somewhat thickened (Fig.1).

3.2 Pedicel

The pedicel has a small triangular base that fits in a comparatively large cavity at the distal end of the scape (Fig.1). Two subtypes of sensilla were distinguished

3.3 The flagellum

It consists of six segments; the first five segments known as the funicle (resemble the pedicel in form), while the sixth flagellar segment is known as the club (Fig.1). Six subtypes of sensillae were recognized on the funicle, S. trichodea 1, 2, 3, S. chaetica 2 and S. coeloconic 1, 3. The characteristic morphological features of sensilla are shown in figures (2D, 3A).

3.4 The club

It is the last segment of flagellum (similar to funnel in shape), longer and broader than other antennal segments (Fig.1). The light microscopic observation revealed that the sensilla are densely and homogenously packed on this area. Also, the electronic microscopic study revealed the presence of four types (seven subtypes) of sensilla highly crowded over the whole of this segment.

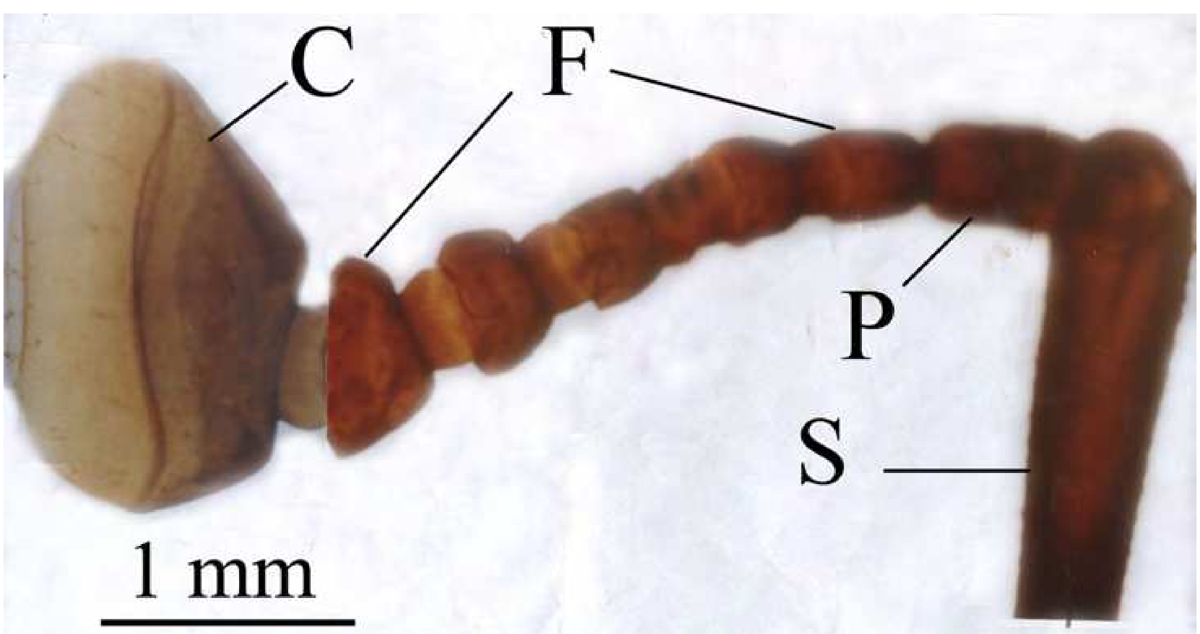

Fig. 1. General morphology of adult antenna *Rhynchophorus Ferrugineus* showing: Scape (S), Pedicel (P), Funicle (F) and Club (C). [Scale bar indicate 1 mm]

3.5 The different types of sensilla

3.5.1 Sensilla coeloconica

Sensilla coeloconica 1 (S.C1) were located in a large and low lumen on both sides of the scape (Fig.2A). S.C1 was distinguished by their finger-like appearance, which characterizes it from the other sensilla. On high magnification, the sensilla appears to be formed of multiple straight tubules directed towards the antennal shaft giving a pyramidal appearance, opening at the apex with many ridges on the surface wall of the sensilla.. Each one arises from a narrow socket; the base of sensilla may be attached to the socket in some parts. The sensilla measures about 16.8 µm in length and about 11.3 µm in diameter (Fig.2A). Two subtypes of these sensilla were distinguished, on the pedicel, the first, Sensilla coeloconica 1 was scattered in a little numbers and have been described previously, the second, Sensilla coeloconica 2 which emerges from a well-defined socket. The fingers are long and tapering apically, some arise from sockets with tilting towards the antennal shaft, and have triangular shape. They have veins ornamented vertically on the surface of the sensilla wall. These sensilla ranged from about 30.8 to 41.3 µm in length, and about 15.8 µm in diameter (Fig.2B). Few numbers of S.C1 are distributed on the 3rd, 4th and 5 th segments of funnels on the flagellum while, S.C 3 are found on the 3rd segment of the funnel. The finger-like processes of S. coeloconica 3 are long and fused into a blunt tip. Number of them is tapering apically, extends with the same diameter and has an elongated triangular appearance. They grow out from wide sockets and extend in a straight line on the antennal shaft (Fig.3A). These sensilla measured about 18 µm in length, and about 5 µm in diameter.

3.5.2 Sensilla basiconica

Sensilla basiconica 1 are found on the ventral side between the scape and the pedicle in one row. It is a hair with a simple bulky base and a wide socket, and this hair ending fans out into two curved parts in line with the curve of the whole sensilla. These sensilla ranged from about 12.5 to 18.8 µm in length, and ranged about 5.0 to 6.5 µm in diameter (Fig.2C). Sensilla basiconica 2 are spread in a very few number on the surface of the club. They are blunt tipped, relatively stout pegged. They are often straight and sometimes slightly curved towards the antennal shaft (Fig.3F).

3.5.3 Sensilla trichodea

They show no special arrangement except that they are more frequent on the apical and basal areas of the segmented funnily on the flagellum.

3.5.3.1 Sensilla trichodea 1

It is formed of straight hair, tapering to a fine end, growing out from a socket in the cuticle. The surface of the sensilla is smooth. It is measured about 240 µm in length and about 12.5 µm in diameter at its base (Fig.2D).

3.5.3.2 Sensilla trichodea 2

It is a straight hair and most of them are blunt-tipped while few of them are bifurcate at the terminal end (Fig.2D). The hair bases inserted tightly into a large cuticular socket and the surface of the sensilla is similar to trichodea 1. They have a mean length about 105 µm and mean diameter about 12.5 µm.

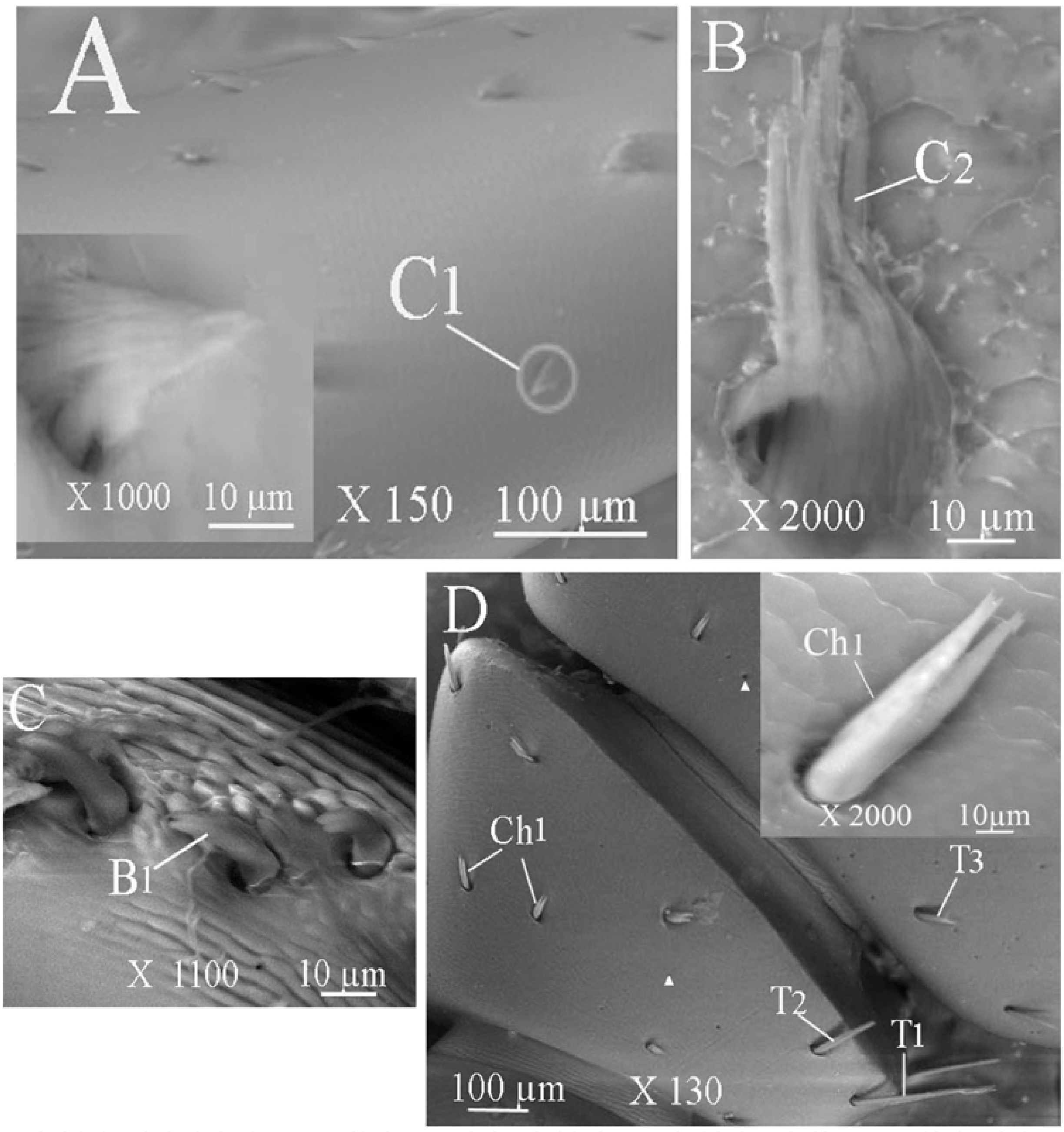

Fig. 2. SEM photomicrographs of non-irradiated adult antenna of *Rhynchophorus Ferrugineus.* (A): Sensilla coeloconica 1 (C1) on the scape, (B): Sensilla coeloconica 2 (C2) on the pedicel, (C): Sensilla basiconica 1(B1) on the ventral side between scape and pedicel, (D): Sensilla trichodea 1, 2, 3 (T1, T2, T3), Sensilla chaetica1 (Ch1) and Cuticular pores as arrowheads on the funicle. [Scale bars indicate 100 µm (A, D) and 10 µm (B, C), respectively]

3.5.3.3 Sensilla trichodea 3

The sensilla of this type are straight, and tapering to a fine point. In some sections, a socket of cuticle is found close to the base of the sensilla. The length measures about 70 µm and the diameter about 12.5 µm (Fig. 2D). Sensilla trichodea 1, 2, 3 observed on the lateral side of the club without any arrangement and have been described previously (Fig.2D).

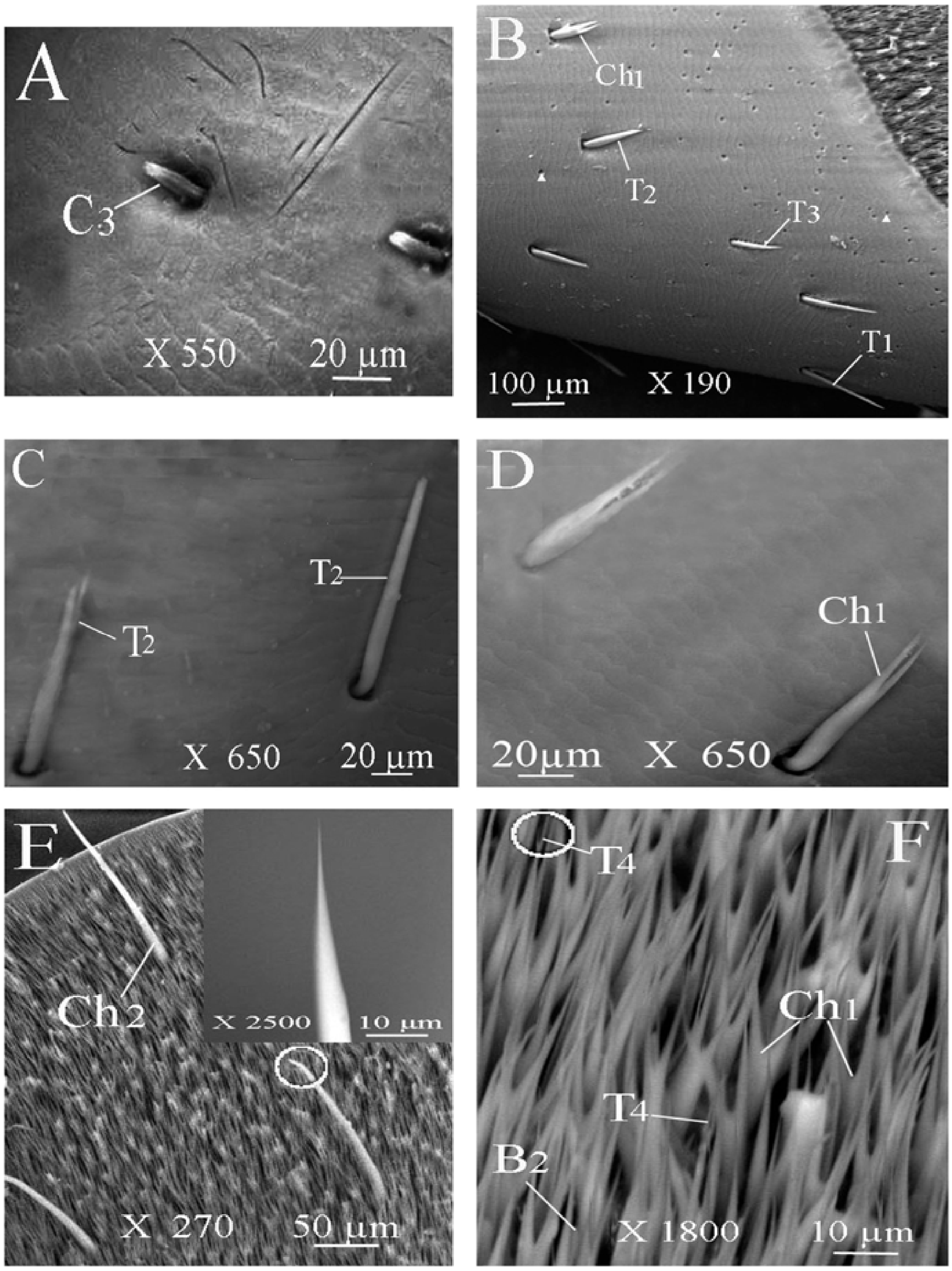

Fig. 3. SEM photomicrographs of non-irradiated adult antenna of *Rhynchophorus Ferrugineus.* (A): Sensilla coeloconica 3 (C3) on the funicle, (B): Sensilla trichodea 1,2,3 (T1,T2,T3) and Cuticular pores as arrowheads on the lateral side of the club, (C): Bifurcat trichodea 2 (T2) on the lateral side of the club, (D): Sensilla chaetica1 (Ch1) on the lateral side of the club, (E): Sensilla chaetica 2 (Ch2) on the surface of the club, (F): Sensilla Basiconica 2 (B2), Sensilla Trichodea 4 (T4) and Sensilla chaetica1(Ch1) on the surface of the club. [Scale bars indicate 20 µm (A, C, D), 100 µm (B), 50 µm (E) and 10 µm (F), respectively]

3.5.3.4 Sensilla trichodea 4

These S. trichodea are present only in a few number on the surface of the club and are smooth –walled. Most of them have about the same length of S. chaetica 1 on the surface of club. The apical part of these sensilla is remarkable split into two branches. These branches are different in length and diameter and they are straight or slightly curved (Fig. 3F).

3.5.4 Sensilla chaetica

3.5.4.1 Sensilla chaetica 1

These sensilla are thick and bifurcate at the half of length, and appear very sharply pointed at their apical margin of equal branches on the flagellum. They are smooth walled and distributed on all the surface of funnel .Some of them is extended in a straight way while the others are gently curved. The length ranged from 32.5 to 50.0 µm and the diameter about 12.5 µm (Fig.2D). These sensilla also, are most abundant on the surface of club; some of them are extended straight while the others gently curved (Fig.3F). S. chaetica 1 resemble that found on funicle (thick, bifurcate from about the middle part of sensilla, and appeared very sharply pointed at their apical margin of equal branches).Also, they could be observed on the lateral sides of the club, the two branches of these sensilla arisen from about middle or third total length and each branch are also divided into two parts (Fig.3D). The S. chaetica 1 on the lateral sides of the club not curved on the antennal shaft and measure about 33.5 µm in length and about 4 µm in diameter.

3.5.4.2 Sensilla chaetica 2

They are long hair-like structures arranged in a line on the surface of the club. They are similar in shape to S. trichodea but much longer in length (approximately three or four times), and found fewer in number compared with other sensilla types. Some of their long axis forms a right angle with antennal shaft while others form an angle of around 60 ºC with the antennal surface to protrude well above all the other sensilla. Distally, it tapers uniformly into simple extremities with pointed tips (Fig. 3E).

3.5.5 Cuticular pores

Abundant cuticular pores vary in their size and location and can be found in-between the sensilla on the whole surface of the lateral side of club and the first segment of the funnel (Figs.2D, 3D). Few numbers of medium-sized pores are noticed on the cuticular depression at the 2nd segment of the funnel (Fig.2D).

3.6 The effects of gamma irradiation on the antennal sensilla

3.6.1 The effects of the dose rate 15 Gray

The following sensilla showed certain alterations while the remaining ones did not show specific changes.

3.6.1.1 Sensilla coeloconica

3.6.1.1.1 Sensilla coeloconica 1

Changes in general appearance, enlarged in size and irregularity in shape were noticed. The base of sensilla became less dense especially in central part. The finger like processes at the apex also became flattened, diffuse, less dense, and not pointing .The sensilla measuring about 20.8 µm in length and about 14.8 µm in diameter (Fig.4A).

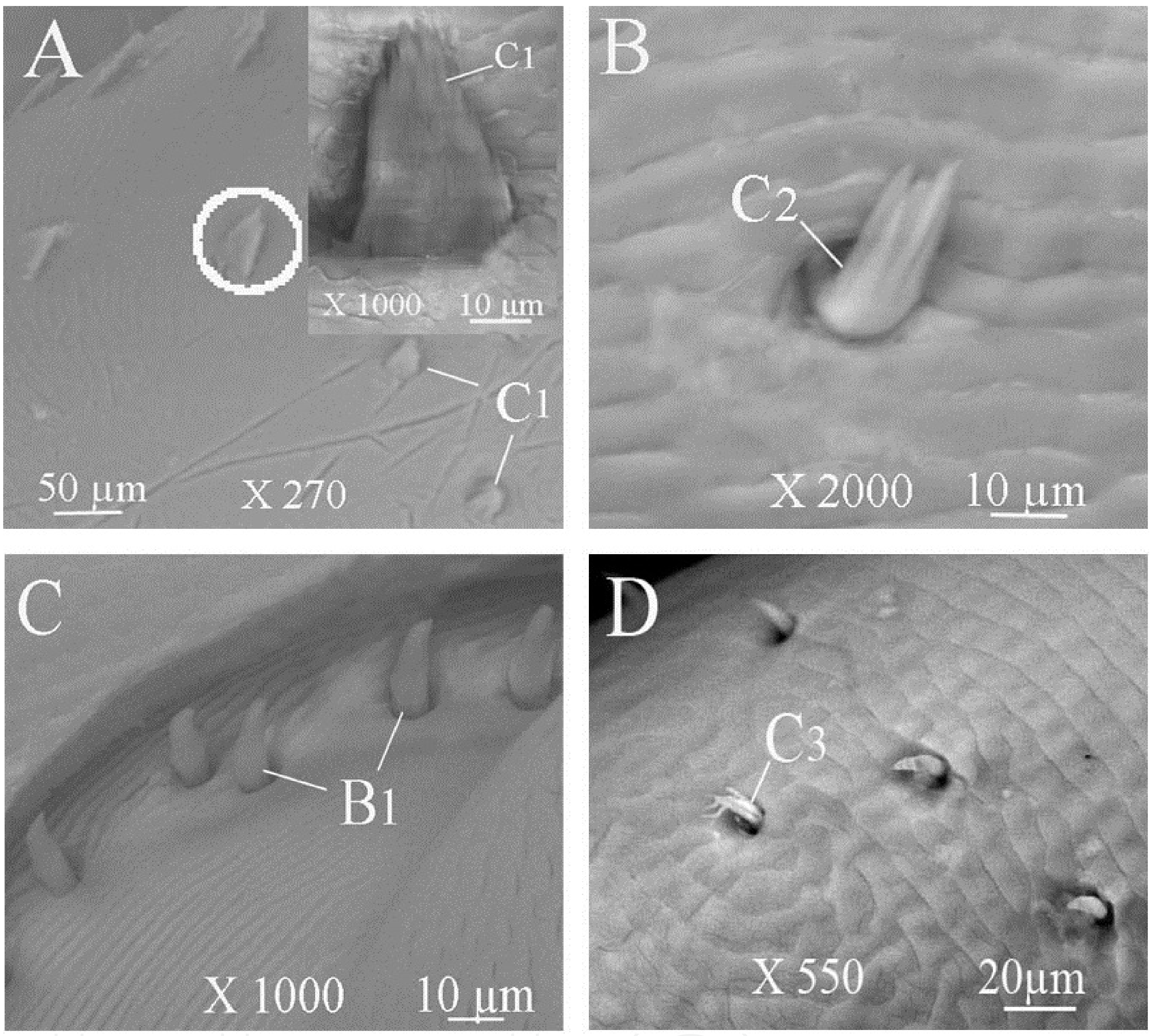

Fig. 4. SEM photomicrographs of irradiated adult antenna of *Rhynchophorus Ferrugineus* with 15 Gy of gamma rays. (A): Enlarged coeloconic1(C1) on the scape, (B): Shrunken sensilla coeloconic 2 (C2) on the pedicel, (C): Shrunken sensilla basiconica 1(B1)on the ventral side between scape and pedicel, (D): Shrunken sensilla coeloconic 3 (C3) on the funicel. [Scale bars indicate 50 µm (A), 10 µm (B, C) and 20 µm (D), respectively]

3.6.1.1.2 Sensilla coeloconica 2

The sensilla are markedly changed in appearance arising deeply from the socket and partly separated from the edges of the socket. The sensilla appear shrunken and diminished in size. Near to the base of sensilla the processes appear fused with each other, fewer in number and thickened out. Near to the apex the processes are fanned out. The processes arise from the socket then, curve upward giving L- shaped appearance. The sensilla varied in length from about 23.8 to 26.3 µm and about 7.5 µm in diameter (Fig.4B).

3.6.1.1.3 Sensilla coeloconica 3

The sensilla observed very shrink. Most the finger –like processes of the S. coeloconica 3 were fused into blunt tip at apical margin, while in a few number were separated from each other and the separated processes were inflect apically (Fig.4D).The sensilla measures about 22.5 μm in length and about 7.3 μm in diameter.

3.6.1.2 Sensilla chaetica

3.6.1.2.1 Sensilla chaetica 1

The S. chaetica 1 on the lateral sides of the club more curved on the antennal shaft and increased in size. The two branches of sensilla arise from the base of sensilla and are equal in length. The sensilla measure about 37.5 μm in length and about 8 μm in diameter (Fig.5A). The S. chaetica1 on the surface of the club become curved as if it needs support from nearby ones (Fig.5D).

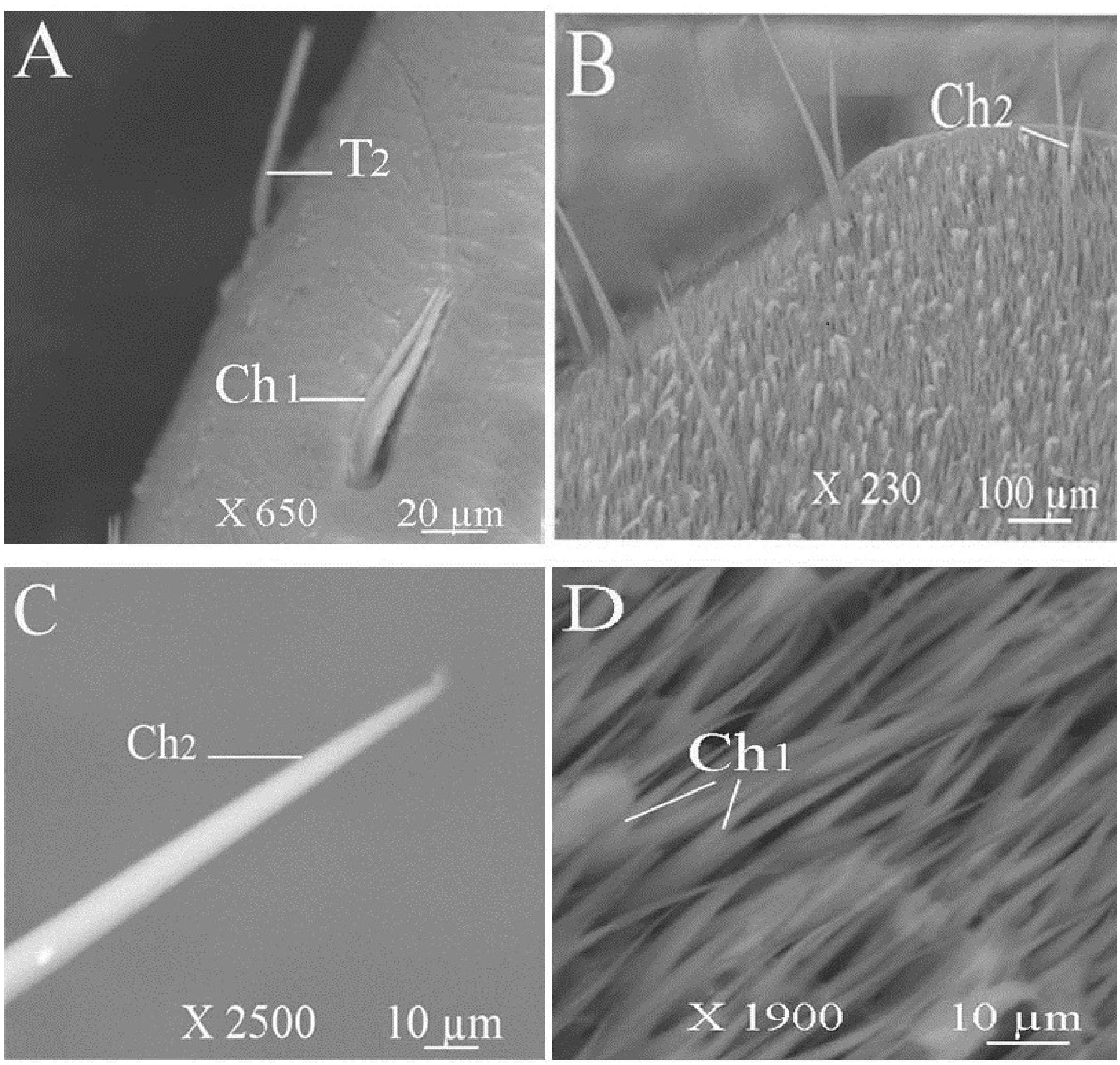

Fig. 5. SEM photomicrographs of irradiated adult antenna of *Rhynchophorus Ferrugineus* with 15 Gy of gamma rays. (A): Enflected sensilla chaetica1 (Ch1) on the lateral side of club,

(B): Swollen sensilla chaetica 2 (Ch2) on the surface of the club, (C): Blunt swollen tip of sensilla chaetica 2 (Ch2), (D): Irregularity of sensilla chaetica1(Ch1) on the surface of the club. [Scale bars indicate 20 µm (A), 100 µm (B) and 10 µm (C, D), respectively]

3.6.1.2.2 Sensilla chaetica 2

The sensilla became shorter, swollen near to the base. The apical part of the sensilla is suddenly interrupted into a blunt swollen tip (Fig. 5C).

3.6.1.3 Sensilla basiconica 1

The sensilla fewer in number and thickened out, shrunken and thinner near to the tip; the bifurcated end appears located more towards the apex. The length measures from about 6.5 to10 µm and the diameter about 2 µm (Fig.4C).

3.6.2 The effects of the dose rate 20 Gray

3.6.2.1 Sensilla coeloconica

3.6.2.1.1 Sensilla coeloconica 1

The sensilla appeared less in number but very tall. The fingers- like processes of the sensilla became very attachment and inflected around each other. The length measures about 35 µm and the diameter about 9.5 µm (Fig.6A).

3.6.2.1.2 Sensilla coeloconica 2

The fingers-like processes of sensilla fused into two groups. In each group these processes are less in number and broad basally which gradually decrease in diameter until reach to fine tipe. The sensilla arise straight and make 45^0C with the antennal shaft. It's length measures from about 28.8 to 30 µm and the diameter about 7 µm (Fig.6B).

3.6.2.1.3 Sensilla coeloconica 3

The fusion of finger- like processes of the sensilla disappeared from about the half length of most sensilla. Some of the separated processes were diverged, extend vertically on the antennal shaft, while the others were converged and form an angle of around 40 ^{0}C with the antennal shaft. The sensilla measures about 14 µm in length and about 2 µm in diameter (Fig.6D).

3.6.2.2 Sensilla chaetica

3.6.2.2.1 Sensilla chaetica 1

The S. chaetica 1 on the lateral side of the club arises from a wide sachet and appeared increased in diameter in the half length reached to about 7 µm. The two branches of the sensilla are not equal in length. The sensilla ranged in length from about 31.5 to 35 µm and about 3.5 µm in diameter (Fig.7A).While the S. chaetica 1 on the surface of club gathered into dense collections and mostly destroyed. Some of the collected sensilla were mostly fused with loss of parts of each sensillum (Fig.7C).In other collection, the sensilla were markedly shrunken and curved into different directions.

3.6.2.2.2 Sensilla chaetica 2

The sensilla were few in number, markedly shrunken. The part near to the socket was swollen, while the apical part disappeared (Fig.7B).

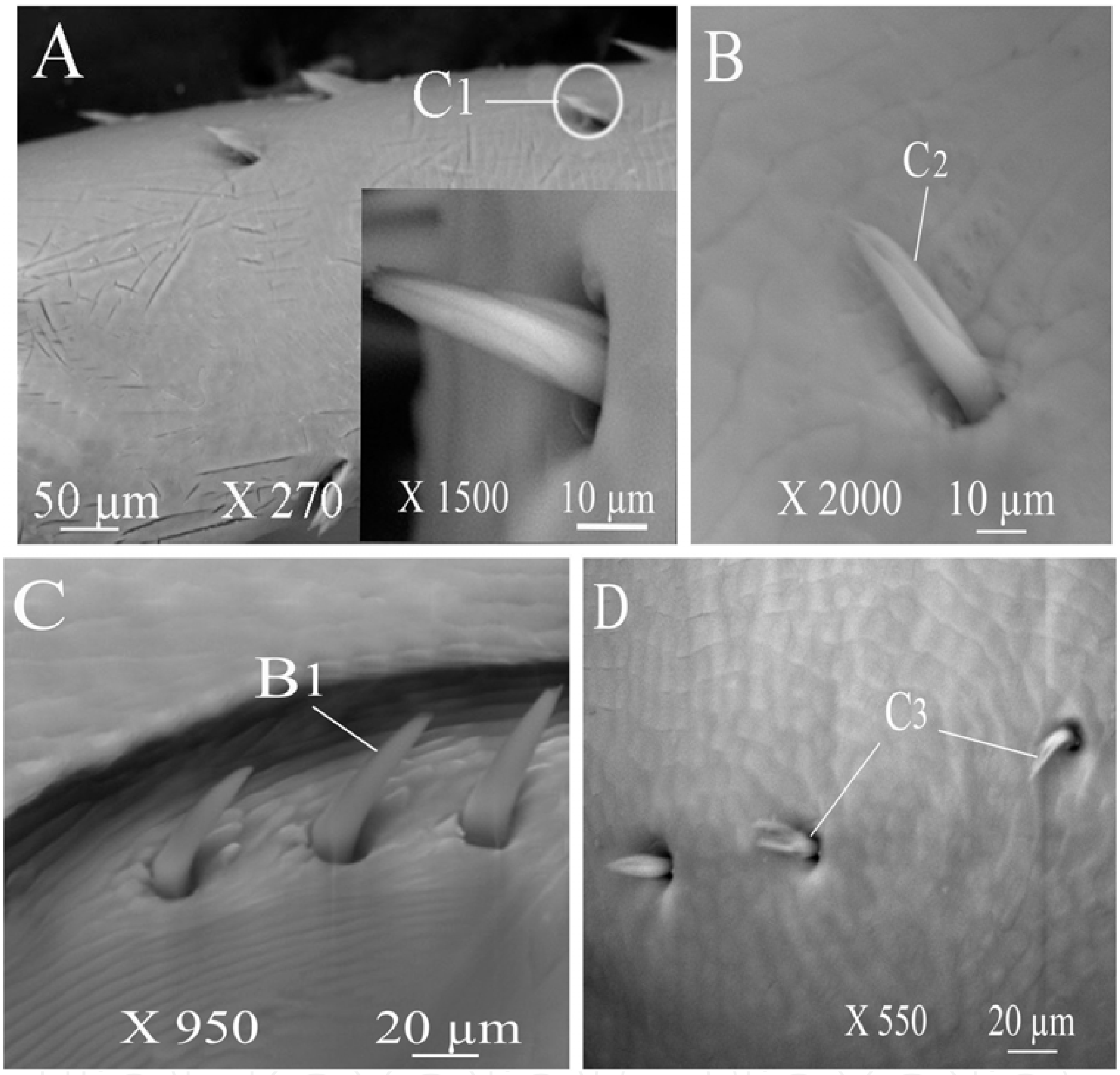

Fig. 6. SEM photomicrographs of irradiated adult antenna of *Rhynchophorus Ferrugineus* with 20 Gy of gamma rays. (A): Tall sensilla coeloconic1 (C1) on the scape, (B): Sensilla coeloconic 2 (C2) on the pedicel, (C): Sensilla basiconic 1 (B1) on the ventral side between scape and pedicel and (D): Sensilla coeloconic 3 (C3) on the funicel. [Scale bars indicate 50 µm (A), 10 µm (B) and 20 µm (C, D), respectively]

3.6.2.3 Sensilla basiconica 1

The sensilla thinned out, some of them lost the bifurcation at the apical part others fade into a blunt tip (Fig.6C). The length of sensilla ranged from about 18.5 to 27 µm in length and about 6 µm in diameter.

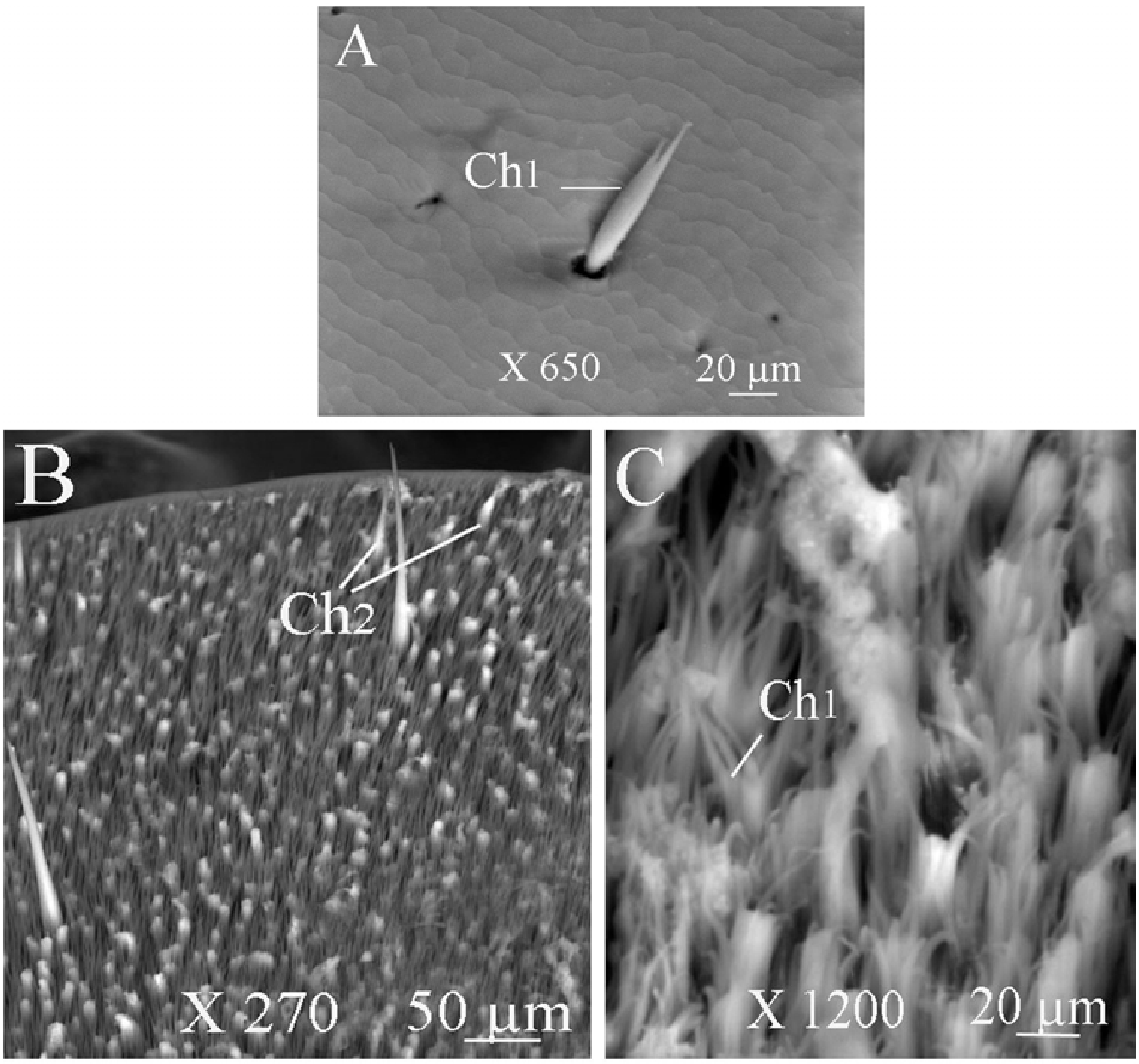

Fig. 7. SEM photomicrographs of irradiated adult antenna of *Rhynchophorus Ferrugineus* with 20 Gy of gamma rays. (A): Abnormal sensilla chaetica1 (Ch1) on the lateral side of club, (B): Shrunken and swollen sensilla chaetica 2 (Ch2) on the surface of club, (C): Sensilla chaetica 1 (Ch1) on the surface of club. [Scale bars indicate 20 µm (A, C) and 50 µm (B), respectively]

4. Discussion

The microscopic observations of the *R. Ferrugineus* antennae revealed four types (eleven subtypes) of hair- like structures and have not shown any sexual dimorphism. These observations are in agreement with behavioral responses of *R. palmarum* to odors in the laboratory and in the field, males and females respond with the same sensitivity to hynchophorol and sugarcane juice in a four-armed olfactometer (Said *et al*., 2003).

The first type of sensilla is coeloconic which large abundance on the scape and pedicel. The morphology of S. C 1 is distinct from the other olfactory sense organs (Jhaveri *et al*., 2000).

Coeloconic sensilla often consist of a peg whose wall is composed of numerous parallel-runing fingers (Keil, 1997). Also, Ameismeier (1985) illustrated that some of the fingerlike projections remained interstitial while some ones combined with each other and remained longitudinal grooves on the surface of the sensilla wall. Hunger and Steinbrecht (1998) observed the coeloconic sensella to be double walled, multiporous, rich in neurons and excessive contact interfaces. Other authors even considered that this type of sensilla may participate in receptivity to heat and humidity (Cuperus, 1983). Olson & Andow (1993) suggested an olfactory function of this sensillar type in *Trichogramma nubilale*, but as revealed in several insect species (Altner *et al.*, 1983), this sensillar type may be involved in thermo- or hygroreception. Coeloconica sensilla are found in many Hymenoptera belonging to several families and have been described by different terminologies, such as, small sub terminal sensilla, (Weselow, 1972), multiporous grooved sensilla (Barlin *et al.*, 1981), bulb sensilla (Cave & Gaylor, 1987) and smooth basiconica sensilla (Norton & Vinson, 1974).

Sensilla trichodea 1 has been described in different insects as having putative mechanoreceptive functions, such as in the perception of mechanosensory stimuli (Onagbola & Fadamiro, 2008). Keil (1999) cited that trichoid sensilla may be olfactory, but sensilla found on the pedicel are usually mainly mechanoreceptive. Schneider (1964) suggests that trichoid sensilla may be dye-permeable and so may posses chemoreceptivity. The great occurrence of the sensilla trichodea on the antennae of male *O. elegans* relative to the females may indicate a probable role in mate location, possibly for the detection of females sex pheromones (Onagbola, *et al.*, 2008).

Sensilla trichodea1 was found on the antennae of *Bembidion* species. These bristles are innervated by a single sensory neuron, ending with the typical tubular body, attached to the base of the hair shaft. This indicates a mechanosensory function (Zacharuk, 1985).

Sensilla similar to sensilla trichodea 2 have been described on several species of curculionid beetles (Alm & Hall 1986 and Isidoro & Solinas, 1992). In electrophysiological experiments with *H. abietis*, Mustaparta (1975) found that this sensillar type was electrophysiologically responsive to odours. Merivee *et al.*, (1999) suggested that they probably function as sex pheromone receptors. In the ground beetle, *Platynus dorsalis*, it might indicate that these sensilla probably respond to aggregation pheromone (Merivee *et al.*, 2001).

Sensilla similar in external morphology to the sensilla trichodea 3 on *R. Ferrugineus* are found on other alticinid species (Ritcey & McIver, 1990). The short sensilla trichodea, recorded from *Synempora* by Davis & Nielsen (1980) are in fact microtrichia, which are very frequently found on flagellomeres. They superficially resemble multiporous small sensilla basiconica which so far have been described only from Agathiphagidae among Lepidoptera (Faucheux, 1990).

The fourth type of trichodea sensilla are found only on the club of *R. ferrugineus* in few number are similar to type V sensilla found on the club of *R. palmarum* ,which characteristics of olfactory trichodea sensilla (Said *et al.*, 2003).Such sensilla were found to house neurons tuned to the pheromone component in *Ips typographus* L. and *Hylobius. abietis* (Mustaparta,1973,1975).

Shields & Hildebrand (2001) showed that every type -trichoid sensilla -of the female sphinx moth *M.sexta* was innervated by two olfactory receptor cells and could respond to aromatic or terpenoid odorants. Similarly, the sensory neuron membrane protein of the wild silk moth *Antheraea polyphemus* was most prevalent in neurons and was localized to receptor membrane of the dendrite cilia presumed to perform the role of olfactive conduction (Rogers *et al*., 2001).

Sensilla chaetica 1 of *R. ferrugineus* are ascribed to mechano-chemoreception in coccinellids,*Semiadalia undecimnotata*, *Coccinella transverguttata* and *P.tsugae* (Jourdon *et al*., 1995; Wipperfurth *et al*.,1987; Broeckling & Salom 2003). In neopseustids, it cannot be excluded that the hair is connected to the considerably elevated socket by a flexible joint membrane and, in this case, the sensilla would be contact mechanoreceptors (Faucheux *et a*l., 2006).

They are resemble in their external sensilla chaetica in *Coccinella transversalis* Fabricius (Coccinellidae) (James, 2001),"chetiform sensilla type I" in *Semiadalia undecimnotata* (Coccinellidae) (Jourdon *et al.,* 1995,"sensilla chaetica type I" in *Agriotes obscurus* Elateridae) (Merivee, 1992) .Some authors treat these also as sensilla trichodea. They are classified, for example, as sensilla trichodea type I in *Carabus fiduciaries saishutoicus* (Carabidae) (Kim & Yamasaki, 1996), and flea beetles (Alticidae) (Ritcey & McIver, 1990).

Sensilla chaetica II could be observed in the antenna of *Cawjeekelia pyongana* (Polydesmida: Paradoxmatidae) (Chung & Moon,2007,2009) and on the labrum of *Synempora andesae* (Neopseustidae),the aporous bifurcate sensilla chaetica could constitute an autapomorphy but would need to be described further in other species of that family (Faucheux 2008).

In the present study the sensilla basiconica 1 and 2 are found on the pedicel and the surface of club. Okada *et al.,* 1992 on the cigarette beetles; *Lasioderma serricorne* and Daly & Ryan, 1979 on the ground beetle, *Nebria brevicollis*, they demonstrated that the wall of these sensilla is perforated by numerous tiny pores. The numerous pores and branched dendrites are considered to be evidence that these basiconica sensilla function as olfactory receptors (Altner & Prillinger, 1980 and Zacharuk,1985).The sensilla basiconica of *Hylobius abietis* were responsive to odours in electrophysiological experiments (Mustaparta, 1975). Moreover, a small groove or depression, not characteristic for mechanoreceptive pegs, at the tip of tiny sensilla basiconica 3 indicate that they propaply function as chemoreceptors (Ploomi *et al.,* 2003).

Curculionid, scolytid and coccinellid beetles have been reported to bear antennal sensilla similar to the sensilla basiconica described here (Alm & Hall, 1986; Bland, 1981; Isidoro & Solinas, 1992, Jourdan *et al*., 1995). Non-articulated blunt-tipped basiconica sensilla, which resemble sensilla basiconica 1, 2 of *Bembidion lampros, B. properans* and *Platynus dorsalis* are common on the antennal flagellum of most insects (Ploomi *et al.,* 2003).

Besides the sensory organs abundant cuticular pores, obviously openings of the antennal glands, penetrate the surface of the antennae of *R. Ferrugineus*. Differences in the size and placement of these pores may suggest differences in the function of respective cuticular glands. In some other insects, antennal glands may have enzymatic activity, degrading molecules of pheromones (Taylor *et al.,* 1981). In Chrysomelidae, antennal glands may produce pheromone (Bartlet *et al*., 1994).

A few ultrastructurally obvious effects of irradiation in the features of normal antennal sensilla of *R. Ferrugineus* could be observed. Typically seen as shrunken, curved of sensilla into different directions, irregularity in shape, swollen in some parts and some sensilla gathered into dense collections. Similar works on the effects of gamma radiation have been recorded by many authors in other insects ; Oland *et al.*,(1988) illustrated the comparison between normal and irradiated *Manduca sexta* with 2.64 Gy revealed that features of normal antennal sensilla were present in irradiated ones with presence some cuticular disruption. Also, El-kholy & Mikhaiel (2008) revealed that gamma irradiation of full grown male pupae of *Galleria mellonella* with the sterile dose 400 Gy and the two substerile doses 100 and 150 Gy showed malformations in the F_1 male antennal sensilla less than that in the parents irradiated with the dose 400 Gy . Besides, the irradiated pupae with the sterilizing dose in *Bactrocera zonata* produced adults with different malformation on the antennal sensilla (El-Akhdar & Afia, 2009).

The present study showed that the malformations in the antennal sensilla induced from exposed of adult with the dose rate 15 Gy were very few, while the dose rate 20 Gy affected on high number of antennal sensilla. And so, the used of high dose (20 Gy) must be turned off because this dose will affect on the behavior of insects. These previous results are compatible with our study in using gamma radiations (15Gy) as part of an Integrated Pest Management program for controlling this pest.

5. Conclusion

The antennal sensilla of unirradiated and irradiated red palm weevile, *Rhynchophorus Ferrugineus* (Oliv.) (Coleoptera; Curculionidae) were investigated by using a scanning electrone microscope. The antenna was composed of three segments; scape, pedicel and flagellum (funicle, club). Four different sensillar types were distinguished. Eleven subtypes, these were; three subtypes of sensilla coeloconica, four subtypes of sensilla trichodea, two subtypes of sensilla basiconica, and two subtypes of sensilla chaetica. The position of these sensilla on the antenna was discussed. These types are used by insects as mechanoreceptor, sex pheromone, aggregation pheromone, olfactory, mate location, thermo-hygroreceptor, and receptivite to heat, and humidity.

There are differences in lengths and diameters of some types of sensilla were recorded as a result of irradiated adult with two doses of gamma rays (15, 20Gy). In the higher dose (20 Gy) more effects of sensilla were recorded for the sensilla chaetica followed by sensilla coeloconica.

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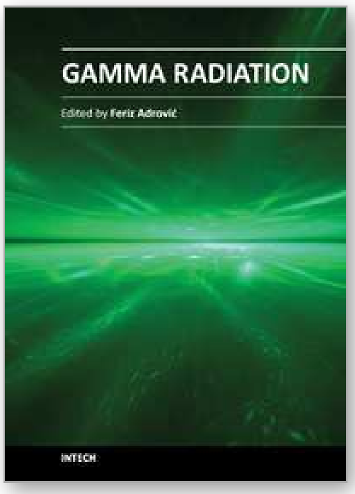

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University Campus STeP Ri
Slavka Krautzeka 83/A
51000 Rijeka, Croatia
Phone: +385 (51) 770 447
Fax: +385 (51) 686 166
www.intechopen.com

InTech China
Unit 405, Office Block, Hotel Equatorial Shanghai
No.65, Yan An Road (West), Shanghai, 200040, China
中国上海市延安西路65号上海国际贵都大饭店办公楼405单元
Phone: +86-21-62489820
Fax: +86-21-62489821