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THE SOUTH AFRICAN CITRUS PSYLLID, TRIOZA ERYTREA (DEL GUERCIO) (HOMOPTERA:PSYLLIDAE)¹FRANK W. MEAD²

INTRODUCTION: THE PSYLLID, TRIOZA ERYTREA (DEL GUERCIO), IS AN IMPORTANT PEST OF CITRUS IN SOUTHERN AFRICA WHERE HEAVY INFESTATIONS CAN CAUSE ECONOMIC INJURY TO NEW GROWTH, PARTICULARLY THAT OF NURSERY STOCK, BY PRODUCING PITTING, CURLING, AND STUNTING OF LEAVES. MORE IMPORTANTLY, THIS PSYLLID IS A VECTOR OF THE MYCOPLASMA-LIKE ORGANISM THAT CAUSES GREENING DISEASE. GREENING WAS DESCRIBED BY ROSSETTI (1975) AS "THE MOST SERIOUS CITRUS PROBLEM IN SOUTH AFRICA WHERE IT AFFECTS THE MAJOR CITRUS SPECIES IRRESPECTIVE OF ROOTSTOCK, REDUCING YIELDS AND MAKING A HIGHER PERCENTAGE OF FRUITS WORTHLESS." NEITHER GREENING NOR THE VECTOR T. ERYTREA PRESENTLY OCCURS IN THE UNITED STATES AND PERHAPS NOT IN THE NEW WORLD; HOWEVER, DISEASES SIMILAR TO GREENING (MORE LIKELY THE CLOSELY RELATED CITRUS STUBBORN DISEASE) HAVE BEEN REPORTED FROM SOUTH AMERICA (BRAZIL, ARGENTINA, PERU). THE LEAFHOPPER-VECTORED CALIFORNIA STUBBORN ALREADY IS A PROBLEM IN "HOT AREAS" OF CALIFORNIA AND ARIZONA WHERE BOVE ET AL (1974) REPORTED SYMPTOM EXPRESSION AS SEVERE.

THE ASIATIC CITRUS PSYLLID, DIAPHORINA CITRI KUWAYAMA, THE VECTOR OF GREENING IN THE ORIENT, WAS REPORTED FROM BRAZIL BY COSTA LIMA (1942). QUARANTINE OFFICIALS SHOULD BE ALERT TO THE POSSIBLE IMPORTATION OF DISEASED CITRUS NURSERY STOCK AND PSYLLID VECTORS ORIGINATING FROM INFESTED COUNTRIES.



FIG. 1. MAGNIFIED UNDERSIDE OF CITRUS LEAF INFESTED WITH TRIOZA ERYTREA (DEL GUERCIO), SHOWING CHARACTERISTIC PITS; SOME EMPTY, SOME WITH NYMPHS.

FIG. 2. SOUTH AFRICAN CITRUS PSYLLID, TRIOZA ERYTREA (DEL GUERCIO). ALL STAGES TO SAME SCALE. A--EGG; B--THE 5 NYMPHAL INSTARS WITH 3RD INSTAR SHOWN AS NEWLY MOULTED; C--GRAVID ♀; D--♂ IN FEEDING POSITION. ILLUS. FROM CATLING & ANNECKE (1968)

DESCRIPTION AND IDENTIFICATION NOTES: CATLING (1972b) REPORTED THAT TRIOZA ERYTREA AND DIAPHORINA CITRI ARE THE ONLY PSYLLIDS KNOWN TO BREED ON CITRUS. HE MODIFIED THIS IN 1974 BY REPORTING THAT 2 NON-VECTOR SPECIES OF DIAPHORINA WERE OBSERVED ON CITRUS IN SWAZILAND. IT IS PERTINENT IN THE FOLLOWING DESCRIPTION OF T. ERYTREA TO INCLUDE SOME OF THE CONTRASTING CHARACTERISTICS OF D. CITRI. ADULT (FIG. 2): BODY LENGTH USUALLY ABOUT 2.2MM BUT VARIABLE FROM 1.9 TO 2.5MM; BODY WIDTH USUALLY 0.5MM (SEE MORAN AND BLOWERS, 1967); FOREWING APPROXIMATELY 3MM LONG, CLEAR, UNSPOTTED (MILKY, HEAVILY MARKED WITH BROWN

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IN D. CITRI); NEWLY EMERGED ADULTS WITH BLACK EYES AND OVERALL PALE GREEN COLOR THAT DARKENS WITH MATURATION, RESULTING IN COLOR OF HEAD, ANTENNAE EXCEPT NEAR BASE, TIBIAE, TARSI, AND DORSAL ABDOMEN BECOMING DARK BROWN TO BLACK; FEMORA MOSTLY PALE YELLOW, WITH BROWNISH STREAK DORSALLY; HIND LEGS STOUTER THAN FRONT 2 PAIRS AND WITH BASAL PORTION OF TIBIAE PALE (IN D. CITRI LEGS EQUALLY STOUT, FEMORA BROWN; TIBIAE AND TARSI PALE YELLOW TO TAN; ANTENNAE MOSTLY PALE YELLOW, DARK BROWN AT TIP). NYMPH (FIG. 1 & 2): LENGTH 0.3 TO 1.7MM, WIDTH 0.12 TO 1.06MM, DEPENDING PRIMARILY ON INSTAR; ALL 5 INSTARS USUALLY PALE YELLOW WITH RED EYE SPOTS, BUT GENERAL COLOR VARIES TO YELLOWISH ORANGE, LIGHT GREEN OR GREY; 2 ABDOMINAL SPOTS APPEAR IN 4TH INSTAR AND BECOME DARKER AND MORE PROMINENT IN 5TH INSTAR; ALL INSTARS WITH COMPLETE FRINGE OF WHITE WAXY FILAMENTS AROUND BODY (LARGE WAXY FILAMENTS ON ABDOMEN ONLY IN D. CITRI); FILAMENTS SHORT AT BEGINNING OF EACH INSTAR, INCREASING CONSIDERABLY IN LENGTH DURING INTERMOULT PERIOD, AND NUMBER OF FILAMENTS INCREASING WITH EACH MOULT (APPROXIMATELY 50 FILAMENTS FIRST INSTAR, 100 2ND, 200 3RD, 300 4TH, 450 5TH, ACCORDING TO MORAN AND BLOWERS (1967)); WING BUDS APPEARING IN 2ND INSTAR; WING PADS OF MATURE NYMPHS "SMALL" (AS OPPOSED TO "MASSIVE" IN D. CITRI); NYMPHS OCCURRING IN OPEN GALL OR PIT, WITH ONLY DORSAL SURFACE EXPOSED ON UNDERSIDE OF LEAVES (IN D. CITRI NO GALL FORMED, NYMPHS COMPLETELY EXPOSED). EGG (FIG. 2): LENGTH USUALLY 0.28MM, WIDTH 0.13MM, ACCORDING TO MORAN AND BLOWERS (1967): SMOOTH AND PALE YELLOW AND OVIPOSITED MOSTLY ALONG EDGES OF YOUNG LEAVES WITH LONG AXIS OF EGG HORIZONTAL TO SURFACE (IN D. CITRI EGGS ARE LAID ON TIPS OF GROWING SHOOTS, ON AND BETWEEN UNFOLDING LEAVES, AND LONG AXIS IS VERTICAL TO SURFACE).

TAXONOMY: SYNONYMS INCLUDE ALEURODES ERYTREAE, TRIOZA MERWEI, SPANIOZA ERYTHREAE AND S. ERYTREAE; SEE CAPENER (1970) FOR CITATIONS AND DETAILS. HE NOTED THAT TRIOZA ERYTREAE WAS ORIGINALLY DESCRIBED AS ALEURODES ERYTREAE IN 1918 FROM A NYMPH THOUGHT TO BE AN ALEYRODID.

DISTRIBUTION: TRIOZA ERYTREAE IS WIDESPREAD IN AFRICA SOUTH OF THE SAHARA (CATLING, (1970b). IT RANGES PRIMARILY FROM THE SOUTHWEST SHORE OF THE RED SEA SOUTHWARD TO THE CAPE OF GOOD HOPE. ELSEWHERE THE COMMONWEALTH INSTITUTE OF ENTOMOLOGY (1967) CITED REPORTS OF IT FROM MADAGASCAR, RÉUNION, MAURITIUS, AND ST. HELENA. WOOLER ET AL (1974) CITED REPORTS OF IT FROM SAUDI ARABIA.

BIONOMICS: MCCLEAN AND OBERHOLZER (1965b) REPORTED THAT TRIOZA ERYTREAE WAS THE VECTOR OF GREENING DISEASE. THIS STIMULATED NUMEROUS STUDIES ON ITS LIFE HISTORY AND BIONOMICS, AND PLANT PATHOLOGISTS INCREASED THEIR RESEARCH ON GREENING. SPACE LIMITATIONS DO NOT PERMIT MENTION HERE OF MORE THAN A SMALL FRACTION OF THE INFORMATION AVAILABLE. SOME OF THE MORE COMPREHENSIVE, RECENT WORKS BY WORKERS IN AFRICA INCLUDE A SERIES OF PAPERS BY CATLING, MCCLEAN, MORAN, SCHWARZ, AND THEIR CO-WORKERS (SEE SELECTED REFERENCES). THE FEEDING OF LARGE NUMBERS OF T. ERYTREAE PRODUCES NO SIGNIFICANT TOXIC MANIFESTATION IN PLANT TISSUE, WHEREAS DIAPHORINA CITRI HAS BEEN REPORTED TO CAUSE CHLOROTIC SPOTS, THE SHEDDING OF FLUSHES AND BLOSSOMS, AND SEVERE DIEBACK. CATLING (1973b) REPORTED THE INCUBATION PERIOD OF T. ERYTREAE VARIED FROM 6-15 DAYS AND NYMPHAL DEVELOPMENT FROM 17-43 DAYS, BOTH BEING STRONGLY CORRELATED WITH MEAN TEMPERATURE. PRE-OVIPOSITION PERIOD WAS 3-7 DAYS AND LONGEVITY 17-50 DAYS. ADULTS MATE SEVERAL TIMES. UNDER INSECTARY CONDITIONS MATED FEMALES LAID 217-1305 EGGS. HE CONCLUDED THAT T. ERYTREAE DOES NOT APPEAR TO POSSESS STRONG DISPERSAL POWERS. CATLING AND OTHERS HAVE NOTED THAT THIS PSYLLID HAS NO DIAPAUSE; THAT ON DORMANT TREES WHEN LITTLE OR NO FLUSH IS AVAILABLE FOR BREEDING SITES, ADULTS FEED FOR LONG PERIODS (2-3 MONTHS) ON MATURE LEAVES. EGG LAYING IS INITIATED BY THE PRESENCE OF FLUSH, AND THE REPRODUCTIVE POTENTIAL IS EXTREMELY HIGH. CATLING (1972b) OBSERVED A MAXIMUM OF MORE THAN 2500 EGGS FROM 1 FEMALE. FROM SEVERAL YEARS OF STUDY HE CONCLUDED (1972a) THAT POPULATIONS WERE MAINLY REGULATED BY 2 DENSITY INDEPENDENT FACTORS: FLUSHING RHYTHM OF CITRUS AND THE OCCURRENCE AND SEQUENCE OF LETHAL WEATHER EXTREMES. POPULATIONS DEVELOP MUCH BETTER IN COOLER WEATHER; HOT SUMMER DAYS CAUSE HIGH MORTALITY. FACTORS OF LESSER IMPORTANCE WERE NATURAL ENEMIES, CITRUS FLUSH QUALITY, INTERSPECIFIC COMPETITION WITH CITRUS APHIDS, AND INTRASPECIFIC COMPETITION. HE PREPARED A POPULATION MODEL FOR T. ERYTREAE. CATLING (1972a,b) REPORTED AT LEAST 8 SPECIES OF PARASITIC CHALCIDOID WASPS ASSOCIATED WITH THE NYMPHS OF T. ERYTREAE, THE EGG AND ADULT STAGES ESCAPING ATTACK. THE PRINCIPAL PARASITE, TETRASTICHUS RADIATUS WATERSTON, OCCURS WIDELY THROUGHOUT CITRUS-GROWING AREAS OF SOUTHERN AFRICA AND IS ALSO AN IMPORTANT PARASITE OF DIAPHORINA CITRI IN INDIA. T. RADIATUS IS RELATIVELY UNAFFECTED BY ROUTINE APPLICATIONS OF INSECTICIDES. CATLING AND ANNECKE (1968) DISCUSSED AND ILLUSTRATED THE LIFE STAGES OF T. RADIATUS. THIS AND OTHER PARASITES WERE REPORTED IN DETAIL BY CATLING (1969b), AND CATLING (1970a) ALSO MENTIONED THAT PREDATORS ASSISTED IN CONTROLLING THE CITRUS PSYLLID BY MIDSUMMER AND ON INTO AUTUMN AND WINTER.

HOST PLANTS: TRIOZA ERYTREAE, IN AFRICA, PREFERS THE VARIETIES OF INTRODUCED CITRUS TO ITS OWN NATIVE HOSTS (RUTACEAE).

GREENING: THIS DISEASE IS VARIABLE IN ITS MANIFESTATIONS BUT TYPICALLY RESULTS IN BITTER, ACORN-SHAPED, LOPSIDED FRUITS THAT MATURE ONLY ON 1 SIDE, WITH THE IMMATURE SIDE REMAINING GREEN WHEN THE FRUIT RIPENS, HENCE THE NAME GREENING. SEEDS TURN BROWN AND ARE ABORTED. LEAF SYMPTOMS OFTEN RESEMBLE ZINC DEFICIENCY. ANGULAR BLOTCHING HAS BEEN CONSIDERED SPECIFIC FOR THE DISEASE AND CONSISTS OF BLOTCHES OF YELLOW ON DARK, GREENISH GRAY LEAVES (SCHNEIDER, 1968). IN TREES AFFECTED WITH GREENING DISEASE THE INFECTION SELDOM IS COMPLETE; SOME BRANCHES SHOW LEAF AND FRUIT SYMPTOMS, OTHERS BEAR NORMAL LEAVES AND FRUIT. IN ADDITION TO VISIBLE SYMPTOMS IN THE FIELD, OTHER DIAGNOSTIC PROCEDURES INCLUDE: GRAFTING OF SUSPECT TISSUE ONTO INDICATOR PLANTS; TRANSMISSION TESTS USING THE PSYLLID VECTOR; IDENTIFICATION OF GENTISOYL GLUCOSE, A VIOLET FLUORESCENT MATERIAL ISOLATED FROM EXTRACTS OF THE ALBEDO OF AFFECTED FRUIT AND/OR BARK FROM INFECTED CITRUS TREES. SCHWARZ AND VAN VUUREN (1970) REPORTED THAT THE STANDARD METHOD USED IN SOUTH AFRICA TO INDEX FRUITS OF SWEET ORANGE FOR THE PRESENCE OF GREENING WAS TO VIEW THE CUT SURFACES OF THE FRUIT UNDER ULTRAVIOLET LIGHT FOR FLUORESCENCE. TESTING OF BARK EXTRACTS HAS BEEN DONE BY THE MORE TEDIOUS CHROMATOGRAPHIC PROCESS. FELDMAN AND HANKS (1969) REPORTED TESTS OF CITRUS TREES IN FLORIDA AND CALIFORNIA WHICH EXHIBITED DISEASE SYMPTOMS SIMILAR TO GREENING. NONE OF THE FLORIDA TREES TESTED, INCLUDING THOSE WITH CITRUS BLIGHT AND YOUNG TREE DECLINE SYMPTOMS, WAS POSITIVE; HOWEVER, POSITIVE TESTS WERE OBTAINED FROM CALIFORNIA CITRUS HAVING STUBBORN DISEASE. ISOLATES FROM CITRUS HAVING

LEAF MOTTLE DISEASE IN THE PHILIPPINES AND DIEBACK AND STEM PITTING IN AUSTRALIA ALSO WERE POSITIVE FOR GENTISOYL GLUCOSE. CITRUS STUBBORN HAS BECOME A SERIOUS PROBLEM IN MOROCCO. CALAVAN (1968) REPORTED THAT GREENING HAS BEEN KNOWN IN SOUTH AFRICA SINCE 1929. BY 1948 THE DISEASE WAS THOUGHT TO BE OF VIRUS ORIGIN BUT LAFLECHE AND BOVÉ (1970A,B) REPORTED THE PRESENCE OF MYCOPLASMA-LIKE BODIES IN SIEVE TUBES OF SWEET ORANGE PLANTS INFECTED WITH THE SOUTH AFRICAN STRAIN OF GREENING. CATLING (PER CAPOOR ET AL, 1974) REPORTED THAT IN SOUTH AFRICA TRIOZA ERYTREA DOES NOT REQUIRE AN INCUBATION PERIOD AND BECOMES INFECTIVE AFTER 24 HOURS ON DISEASED TISSUES. THE GREENING PATHOGEN PERSISTS FOR AT LEAST 2 TO 3 WEEKS IN ADULTS, BUT NYMPHS DO NOT APPEAR TO TRANSMIT IT, AND THERE IS NO EVIDENCE FOR TRANSOVARIAL TRANSMISSION. CAPOOR ET AL (1974) REPORTED THAT IN INDIA DIAPHORINA CITRI REQUIRED AN INCUBATION PERIOD OF ABOUT 21 DAYS, AND THAT 4TH AND 5TH INSTAR NYMPHS CAN ACQUIRE THE PATHOGEN AND BECOME VECTORS FOR LIFE AFTER A LATENT PERIOD OF 5 TO 9 DAYS. GREENING DISEASE AND STUBBORN DISEASE OF CITRUS HAVE SEVERAL CHARACTERISTICS IN COMMON BUT DIFFER IN THE OPTIMUM TEMPERATURE FOR THE EXPRESSION OF SYMPTOMS, GREENING REQUIRING COOLER TEMPERATURES, DEVELOPING BEST A LITTLE BELOW 22-24°C, WHEREAS STUBBORN SYMPTOMS ARE BEST EXPRESSED AT 30-35°C. THERE ARE SEVERAL STRAINS OF THE GREENING CAUSAL AGENT, SOME OF THEM PREVALENT IN ASIA ALSO, AND SOME RESIDE VIRTUALLY SYMPTOMLESS IN THEIR HOSTS, REQUIRING SPECIAL DIAGNOSTIC TECHNIQUES TO BE PROVED POSITIVE. RECENTLY SCIENTISTS PROVED THAT CITRUS STUBBORN IN CALIFORNIA IS CAUSED BY A MYCOPLASMA-LIKE ORGANISM CALLED SPIROPLASMA CITRI SAGLIO, LAFLECHE, BONISSOL, AND BOVÉ, AND THAT IT IS TRANSMITTED BY LEAF-HOPPERS (CICADELLIDAE). SPIROPLASMAS ARE HELICAL, MOTILE, WALL-FREE PROKARYOTES RECENTLY RECOGNIZED AS A DISTINCT NEW GROUP OF MICROORGANISMS REFERABLE TO THE MOLLICUTES. BOVÉ AND SAGLIO (1974) REVIEWED DIFFERENCES BETWEEN THE MYCOPLASMA-LIKE BODIES CAUSING GREENING AND STUBBORN, WITH THE GREENING ORGANISM, IN PARTICULAR, BEING MORE REMOVED FROM TRUE MYCOPLASMAS. KNORR (1967) DISCUSSED SYMPTOMS OF GREENING AND THE POSSIBILITY OF IT AND/OR STUBBORN BEING IN FLORIDA. HE AND OTHERS HAVE OBSERVED FLORIDA CITRUS HAVING SYMPTOMS SIMILAR TO THESE DISEASES, BUT THE NEGATIVE TESTS OF FELDMAN AND HANKS (1969) HAVE HELPED TO DISPEL THE THOUGHT THAT THESE DISEASES ARE PRESENT IN FLORIDA. IF GREENING-INFECTED CITRUS STOCK WERE TO MAKE ILLEGAL ENTRY INTO FLORIDA, BUDDING AND GRAFTING COULD SPREAD THE PATHOGEN, BUT IT IS DOUBTFUL IF GREENING WOULD BECOME A MAJOR PROBLEM WITHOUT THE ACCOMPANYING INTRODUCTION AND POPULATION EXPLOSION OF ONE OF THE PSYLLID VECTORS. THE ASIATIC STRAINS OF GREENING ARE MORE OF A THREAT. THE SOUTH AFRICAN STRAIN OF GREENING IS NOT READILY TRANSMISSIBLE BY BUDDING AND GRAFTING, BUT CAPOOR ET AL (1974) REPORTED THAT A HIGH PERCENTAGE OF TRANSMISSION WAS OBTAINED IN INDIA BY BARK, LEAF-PATCH, AND SHOOT GRAFTING. REGARDING STUBBORN, THE VECTOR ON CITRUS IS THE LEAFHOPPER, SCAPHYTOPIUS NITRIDUS (DELONG), KNOWN FROM GUATEMALA (PERSONAL COMMUNICATION WITH DR. C. A. MUSGRAVE, 1976), MEXICO, AND CALIFORNIA. STUBBORN SYMPTOMS IN ARIZONA, IMPLY S. NITRIDUS IS THERE ALSO. SEVERAL OTHER SPECIES OF SCAPHYTOPIUS ARE PRESENT IN FLORIDA. THEY ARE NOT KNOWN TO BREED ON CITRUS AS S. NITRIDUS DOES. THERE IS A GREATER STATISTICAL CHANCE THAT BOTH STUBBORN AND A VECTOR COULD BECOME ESTABLISHED IN FLORIDA COMPARED TO GREENING AND ITS VECTOR, ALTHOUGH REGULATORY AGENCIES ARE EXERCISING THE GREATEST DILIGENCE TO PREVENT ILLEGAL ENTRY OF DISEASED CITRUS AND UNWANTED INSECTS. KNORR (1967) WROTE THAT, "GROWERS WOULD BE WELL ADVISED TO LEAVE THE SELECTION OF BUDWOOD TO AN AGENCY SUCH AS THE BUDWOOD REGISTRATION PROGRAM THAT IS ALERT TO THE RECOGNITION OF GREENING SYMPTOMS AND THAT SEEKS TO AVOID SUSPICIOUS SOURCES OF BUDWOOD REGARDLESS OF THE CAUSE." THE ILLEGAL ENTRY OF 'STAR RUBY' GRAPEFRUIT STOCK INTO FLORIDA IS A CASE IN POINT (SEE JONES, 1976). HANNON (1976) MENTIONED CITRUS DISEASE PROBLEMS IN BRAZIL RESULTING FROM SMUGGLING OF ILLEGAL MANDARIN BUDWOOD INTO THAT COUNTRY.

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