Insect Management on Desert Produce Crops:
Aphids

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Aphids have seemingly always caused problems for desert vegetable growers. Several aphid species occur during the winter and spring growing seasons. Because of their ability to contaminate harvestable plant parts, preventing aphids from colonizing plants is critical. Cultural management tactics and natural enemies can reduce the impact of aphids, but control with insecticides is usually required to prevent economic damage in spring crops. Green peach aphid has generally been considered the most important aphid species of the complex because of its relative tolerance to some of the older insecticide chemistries, and its ability to reach high population levels in produce crops. More recently however, two additional aphid species have emerged that now pose a serious threat to winter vegetables – the lettuce aphid and the foxglove aphid. In cole crops, cabbage aphid and green peach aphids are the most common species that cause serious damage and to a lesser extent, melon aphids can be found infesting celery.

Green Peach Aphid, *Myzus persicae*

Distribution

Green peach aphid (GPA) originated in Asia, and can be found wherever vegetables are grown in the desert. This is important since GPA is reported to be transported long distances by wind and storms. GPA can be found developing on hundreds of host plants in over 40 plant families including the following desert vegetable crops; artichoke, broccoli, cabbage, carrot, cauliflower, cantaloupe, celery, cucumber, fennel, kale, kohlrabi, turnip, lettuce, mustard, parsley, parsnip, pepper, potato, radish, spinach, squash, tomato, turnip and watermelon. GPA can also be found on a large number of ornamental and landscapes plants. Weeds such as field bindweed, lambsquarters, redroot pigweed, and cheeseweed are also considered important hosts.

Description and Seasonal Development.

Research has shown that due to high temperatures GPA doe not survive in appreciable numbers during the summer in the desert and becomes virtually extinct. GPA become abundant again in October and November as a result of migrations from the coastal and mountainous area of California with strong fall and winter winds. In desert climates it reproduces asexually and thus all generations of GPA that occur on desert vegetables or melons are parthenogenetic (they lay live nymphs, rather than eggs; Plate 3A) and their life cycle is typical for most all aphid species. Nymphs initially are very small and light green (Plate 3B). As they mature the wingless (apterous) aphids are usually a dull green and medial and lateral green stripes may be present on the abdomen (Plate 2, 3D). The legs are pale. Four instars occur with GPA, each lasting about 2-3 d under normal winter and spring growing conditions. Populations consist entirely of female aphids giving live birth to female progeny. This type of reproduction gives aphids a tremendous reproductive capacity. Adult wingless (apterous) females give birth to live nymphs about 10 days after birth and can easily deposit 80 to 100 young in her lifetime of about 30 days. Numerous overlapping generations can occur from November through March. GPA populations tend to develop most rapidly

when temperatures average about 55 °F. In response to crowding by other aphids or declining host plant quality, migratory (winged) forms are produced that move to new hosts (weeds or crops). This ordinarily occurs in the early spring. This dispersing form of GPA, is also capable of moving from field to field through a growing season. Winged GPA have a black head and thorax, and a light green to yellow abdomen with a large dark patch dorsally. At the base of each antenna of many aphids is a small bump called a tubercle (Plate 1, 3C). In green peach aphids these tubercles are pronounced and converging inwardly, while similar species tubercles are less pronounced or diverging. Wingless adults are light green or red with the same antennal bumps(Plate 2, 3D).. Nymphs appear as smaller versions of the wingless adults. A pictorial key for identification of GPA is shown in Plates 1 and 2.

Economic Damage

Aphids feed by piercing plants with needlelike mouthparts and sucking plant juices. GPA tends to be distributed uniformly on the undersides of older leaves in lettuce and cole crops where they can rapidly spread to younger leaves and heads when populations increase under ideal conditions. Aphid feeding on seedling leafy crops rarely kills plants and older plants can withstand feeding by large numbers of aphids. However, contamination of harvestable plant material with aphids, or with aphid honeydew is the primary damage caused by GPA. Occasionally blemishes to the plant tissue, usually in the form of yellow spots, may result from aphid feeding. GPA is usually an economic problem on crops during the late fall (Nov) and again in late winter and spring (Jan-Apr).

- Lettuce: Colonization generally starts on the lower, older leaves and populations move up into the heads or younger leaves near harvest. In heavy infestations, they may be found throughout the plant. GPA damages lettuce primarily by acting as a contaminant on the harvested leaves, hearts, or heads. Shippers will accept very little aphid contamination on the harvested portion of the plant. Additionally, GPA serves as vectors for alfalfa mosaic virus, lettuce mosaic virus, and beet western yellows virus that affects lettuce. This is generally not a problem in desert growing areas where virus-free seed is planted.
- Cole crops: Infestations are usually found on the oldest leaves. GPA can commonly be found colonizing seedlings, transplants, and lower leaves of older plants, and under heavy pressure can be found in heads of broccoli, cauliflower, and cabbage. Contamination of these harvested plant parts is not acceptable for most markets. GPA can also be an economic problem on *Brassica* seed crops where their feeding and honeydew can significantly reduce seed yields.
- Spinach: GPA colonizes all plant parts, including the terminal growth. High numbers of aphids can stunt seedlings and will contaminate product bound for market. Green peach aphids vector several viruses that may affect spinach.
- Celery : GPA can build up to very high densities in mature plants. They stunt plant growth on late fall transplants and have been known to transmit virus diseases such as western celery mosaic, celery calico, and cucumber mosaic. They are most damaging when they contaminate celery hearts which is unacceptable under most market conditions.

Potato aphid, *Macrosiphum euphorbiae*

Distribution

Potato aphid (PA) occurs throughout the United as thought to be native to North America. PA is polyphagous, but its favored hosts are potato and tomato. In the desert, PA can be found feeding on celery, corn, cucumber, kale, lettuce, mustard, pepper, potato, pumpkin, spinach. It also infests a number of ornamental flowers such as geranium, gladiolus, hollyhock, iris, lily, and roses. Among the weed hosts, PA can be found on are black nightshade, ground cherry, jimsonweed, lambsquarters, pigweed, *Amaranthus* spp., shepherdspurse, *and* wild lettuce. PA is capable of moving from host to host as the quality of the plants deteriorates due to seasonal changes.

Description and Seasonal Development

In desert climates PA reproduces asexually and thus all generations that occur on desert are

parthenogenetic and their life cycle is similar to GPA. Four instars of the apterous nymphal stage occur and yellowish-green or yellowish-pink in color (Plate 4B). The cornicles are long and with dark tips. Similar to PA, apterous nymphs develop rapidly, requiring about 2 days to complete development of each instar. PA nymphs and adults are bigger than the GPA and the adult has much longer cornicles and cauda (Plates 4C, 4D). PA adults typically produce two different color forms-one green and the other pink. The adult wingless (apterous) form is green or pink, and free of any markings on the legs or abdomen. The cornicles are quite long, and with dark at the tips. The tubercles at the base of the antennae diverge outward, unlike GPA. They live for about 30 days, with 10 days in the nymphal stage and the remainder as apterous adults. They can produce as many as 80 progeny during their lifespan. The adult winged (alate) form also has the same pink or green body with cornicles that are darker at the tips (Plates 4A, 4C). Like GPA, hot weather does not favor PA and populations decrease when average temperatures exceed 60 F. A pictorial key for identification of GPA is shown in Plates 1 and 2.

Economic Damage

PA colonies are composed of apterous adults with offspring closely clustered around them and they are usually found on the older leaves.

- Lettuce: The damage by PA is similar to that caused by green peach aphid in that it may cause unacceptable contamination of harvested leaves or heads. They are not known to transmit any diseases to lettuce.
- Cole crops: PA are not known to colonize cole crops in the desert.
- Spinach: The damage by PA is similar to that caused by green peach aphid in that it may cause unacceptable contamination of harvested leaves or bunches.
- Celery: If PA densities are high enough they can infest celery hearts deeming them unacceptable for harvest.

Foxglove Aphid *Aulacorthum solani*

Distribution

The foxglove aphid (FGA) is found almost world-wide, but was first found infesting commercial lettuce fields in the desert in 2002. Although it has been reported on a wide range of hosts in California for many years, it was not previously thought to occur in Arizona. Based on recent observations in Yuma, it now appears that FGA has become established in the desert and is considered a serious aphid pest in desert produce crops. This species is principally considered a serious pest of potatoes throughout the U.S, and is only considered an occasional pest of lettuce and leafy vegetables grown in Canada. FGA will also occur on citrus, celery and tomatoes, and has been reported on flowers such as Easter lily, foxglove, gladiolus, pansy, salvia, tulip, and violet. A number of common desert weed hosts will also harbor FGA including common chickweed, dock, dandelion, pigweed, purslane, and shepherdspurse.

Description and Seasonal Development

Like other aphid species found on desert vegetables FGA reproduces asexually and is parthenogenic throughout the year. There are five nymphal instars with an average developmental time of 12-13 days during normal spring growing conditions (~60 F). Apterous adults begin producing progeny almost immediately. Apterous adults are pear-shaped and the tubercles at the base of the antennae are straight-sided, facing neither inward as in GPA, nor outward, as in PA. The abdomen is green in color with a pale head and thorax. The cornicles are moderately long, thin, and tapered, varying in color from almost colorless to dark, and with dark tips. The distinguishing characteristic of FGA is the dark green patches at the base of the cornicles (Plate 2, 5B, 6D). On spring crops a newly emerged adult can be reproductively active for 2-3 weeks and can produce an average of 60 offspring. Winged adults are similar in size and the abdomen is pale green, olive green, or green, but the head and thorax vary from dusky-yellow to almost black with a brown tinge (Plate 1, 5A,C). The winged adult usually has dark bands across the abdomen. A pictorial key for identification of FGA is shown in Plates 1 and 2.

Economic Damage
FGA populations in potatoes can cause young potato leaves to curl apparently from toxic saliva as it feeds. This aphid also transmits numerous plant viruses, but none have been associated to date on desert crops.

- Lettuce: FGA are serious pests of all spring lettuce types (leaf, romaine and head) and typically begin showing up in December, but are generally most active in Feb and March. They are more mobile on lettuce plants and tend to disperse more throughout the plant. They tend to colonize more intensively in lettuce heads and romaine hearts than either GPA or PA. FGA damage lettuce by contamination of harvested plant parts.
- Cole crops: FGA have not been found to infest cole crops.
- Spinach: FGA have not been found to infest spinach.
- Celery: FGA are serious pests of desert celery. They primarily colonize the protected young growth on maturing plants and will contaminate celery hearts at harvest rendering them unmarketable.

Lettuce Aphid *Nasonovia ribisnigri*

Distribution
A new exotic aphid species, the lettuce aphid (LA) was found infesting lettuce in the Salinas valley of California in 1998. This aphid quickly spread throughout the coastal growing areas and is now considered their primary aphid pest. LA is of European origin and is commonly found on lettuce in Europe and Canada. This pest had never been reported in the western U.S, but by 2000, the lettuce aphid was found in Yuma lettuce crops. LA has a very narrow host range with lettuce and radicchio being the only desert vegetables affected; sowthistle and petunias are also colonized. LA occurs annually in the lower desert and is now considered a key pest of late spring lettuce in the desert.

Description and Seasonal Development
Very little information on the LA biology under desert conditions has been reported. However, LA appears to be most reproductively active when temperatures average above 55-60 °F. They have a very short lifecycle (~8-10 days) and populations can build up rapidly. Under mild-winter temperatures, LA can be present on lettuce throughout the winter and spring crops. The nymphs are comparatively large and can take on different color forms , ranging from red to pink to brown (Plate 6D). Adults, both apterous and alate are usually brown with a dark head and thorax (Plates 6A, 6C). Extensive black markings can be found on adult, often including dark cornicles, dark bands across the abdomen, and dark bands on the legs. The antennae and cornicles are long in LA, and the legs are quit spindly giving it a spider-like appearance. A pictorial key for identification of LA is shown in Plates 1 and 2.

Economic Damage: Unlike other aphid species in lettuce, LA tends to deposit live nymphs near the growing point of plants. They continue to feed and reproduce deep within the plant on young newly developing leaves. In head lettuce and romaine, LA is found almost exclusively in developing heads and heart, often well protected under several layers of leaves. They economically damage lettuce as a contaminant, often rendering whole fields unmarketable. In addition to contamination of lettuce heads, lettuce aphids cause injury by transmitting such lettuce-infecting viruses as cucumber mosaic.

Cabbage Aphid *Brevicoryne brassicae*

Distribution
Cabbage aphid (CA) is thought to originate in Europe and can be found throughout the United States and Canada. Nearly all crops in the family *Cruciferae* are hosts for CA and the desert vegetable crops most severely affected are broccoli, cabbage, and cauliflower, but collards, kale, kolhrabi, mustard, rape, and turnip are attacked. Numerous cruciferous weeds, especially London rocket, shepherdspurse and other mustards serve as suitable hosts. CA is considered the primary aphid pest of cole crops and *Brassica* seed crops grown in Arizona.

Description and Seasonal Development
There are four nymphal instars, each lasting about 3 days long. Young nymphs are green colored and lack the typical grayish-white, waxy covering, but soon appear waxy when they begin feeding (Plate 8A). The resulting adults are all female and they reproduce parthenogenetically, producing as many as 20 generations per year in desert growing areas. Adult wingless (apterous) females give birth to as many as 50 nymphs during their life span, which can last as long as 40 days. The wingless females are grayish green, with a dark head, and palebrown legs. The cornicles are dark and measure is relatively short. There is a double row of dark bars on the back, and the body is covered with a white waxy droplets. Most aphids found on winter vegetables are females and winged adults are formed at high population densities or when plant quality deteriorates. The winged (alate) females are similarly dull green, but the legs are dark. The cornicles are dusky-green to black. The entire body is covered with a fine white waxy dusting. The winged forms have a shorter life span than the wingless form and also produce relatively few offspring.

Economic Damage
CA populations are capable of building up to very high densities. Heavily infested plants can appear to have a gray appearance due to the mass of aphid bodies on the foliage. Large colonies may significantly stunt small seedlings or newly established transplants. CA also produce more honeydew and sooty mold than other aphids found in the desert. Under heavy infestation levels leaves will wrinkle and curl, often cupping downward. CA prefers the youngest tissue and highest portions of the plant, and can be found on both upper and lower surface of leaves. The main damage caused by CA is contamination; where colonies in heads of cabbage, broccoli, and cauliflower cannot be removed. Untreated infestations can cause significant marketable yield losses. Over 30 viruses are known to be transmitted by Ca, but are seldom observe on desert crops.

Turnip Aphid *Lipaphis erysimi*

Distribution
Turnip aphid (TA) is native to Europe and can be found throughout the desert growing regions. It is often confused with cabbage aphid, and in some areas is more important than cabbage aphid as a vegetable pest. This aphid has also been found associated with all *Brassica* crops, including broccoli, cabbage, cauliflower, collards, kale, kohlrabi, mustard, radish and turnip. It is commonly found on cruciferous weeds such shepardspurse and london rocket. Although it has been reported on lettuce and other leafy vegetables, it is not known to colonize these hosts.

Description and Seasonal Development
TA can be very prolific. Nymphs are pale green in color and go through four nymphal instars and have a lifespan of about 30 days (Plate 17C). Under the normal desert growing conditions numerous generations can be produced. They are reproductively active about 5-6 days after nymphs reach maturity and can produce more than 80 young during their lifetime. The wingless (apterous) adult females are green with rows of dark bands across the abdomen. The legs are pale, the antennae are dark, and the cornicles pale with dusky tips. The entire body can sometimes be lightly covered with a white secretion. The winged (alate) adult females are pale green, with a black head and thorax. The legs are brownish to blackish, and the antennae are black. TA generally can be differentiated from cabbage aphid by the lack of waxy droplets on the body, and longer cornicles.

Economic Damage
TA primarily feed and colonize on the undersides of leaves, but move to the center of the plant and feed on both the upper and lower surfaces of tender young foliage under heavy infestations. They will also feed on the stem tissue of the flowers on seed crops. Heavy infestations can kill small plants, and on newly established transplants can cause leaves to cup and turn yellow (Plate 9C). Contamination of foliage by aphid bodies, cast skins and honeydew is main damage caused by TA.

Management of Aphid Complex

Monitoring/Sampling

Yellow sticky traps can be used to monitor movement of winged adults into an area. Colonies of wingless aphids on plants often occur following sharp increases in the number of winged aphids caught on traps in the spring. Used properly, yellow traps placed within fields near upwind edges, can provide an early indication of when colonization by aphids is beginning. However, proper identification of aphid species is important because many aphid species are also dispersing to wheat and alfalfa crops in late fall (pea aphid, blue alfalfa aphid, greenbug, etc.). Scouting during the season should entail visual sampling of individual plants for presence of winged adults and colonizing apterous aphids. This is the most reliable method of determining aphid economic status. In leafy vegetables and cole crops, examine entire plants, particularly the underside of older leaves and the innermost new leaves. During head formation, sampling should include examining wrapper leaves and dissecting heads. In melon crops, the undersides of individual leaves should be sampled. Growers should inspect cole crop and watermelon transplants before planting to assess presence of aphids and other pests.

Aphid infestations begin with the movement of a few winged females into fields that give birth to live nymphs. Many of these offspring will become mature, wingless aphids that in turn will deposit more live nymphs. Thus, infestations can develop quickly when conditions are favorable. Consequently, fields should be sampled frequently, at least 2-3 times per week during the winter and spring.
Monitoring for all aphid species should begin after seedlings emerge. Check weeds on ditch banks and field borders for winged adults prior to stand establishment. Once seedlings emerge, sample plants randomly across the entire field. Additional samples should be taken from areas of the field most likely to be infested, or areas in where colonies have previously been found. Aphid populations are often clumped along the field margins nearest the direction of prevailing winds and adjacent to other host crops or weeds Sampling should be done separately for different plant varieties, planting dates, or other unique areas within fields. Sampling frequency should also consider insecticide applications and re-entry intervals. Proper identification of aphid species found in the field is important as this may influence the choice and timing of control measures.

Rainfall can influence aphid population numbers. Recent trends have suggested that aphid infestations can be expected to be lighter when little or no rainfall occurs during the season. Fall and winter rainfall create an abundance of native and weedy hosts which can provide a reservoir of aphids that can continually migrate into desert produce. In dry years, it is unusual to experience an abundance of desert flora or aphid numbers. Similarly, aphid abundance seems to be greater when windy conditions prevail.

Cultural Practices

Some aphids can be removed from harvested crops destined for processing plants by washing or hydro-cooling. However, this is not practical for field-packed leafy vegetables. Row covers and reflective mulches have been used in spring melon crops to exclude immigrating aphids in order to prevent or delay aphid infestation or virus transmission. Destruction and removal of crop residues immediately after harvest can minimize the spread of aphids to adjacent plantings. In leafy vegetables, green peach aphids can be very numerous in fields containing weedy mustards and members of the goosefoot family. Control of these weeds may help prevent buildup of green peach aphid.

Natural / Biological Control

Although aphid populations tend to higher in years with heavy winter rainfall, warm and wet weather can be also be unfavorable for aphid buildup due to losses of aphid colonies to fungal pathogens. Aphids have many natural enemies. Most of the common lady beetles, lacewings, flower flies, and numerous parasitoids such as *Aphidius spp.* and *Aphelinus* spp. naturally attack these aphid species. Despite the large number of natural enemies that attack aphids, aphid populations generally grow more rapidly than populations of their natural enemies, especially in cool weather. *As a result, under*

desert growing conditions natural enemies rarely provide adequate control of high field populations of the aphid in spring crops. Predators and parasitoids do a better job of aphid control during warmer weather and may partially explain why aphids occur only sporadically in spring melons.

Insecticidal Control

There are two different management approaches for controlling aphids in desert vegetables with insecticides. Both of them are *preventative* approaches that utilize insecticides to prevent aphids from colonizing and contaminating plants. The first management approach involves the soil application of systemic neonicotinoid insecticides (i.e., imidacloprid (Admire); thiamethoxam (Platinum)). These compounds have low environmental risk. Long residual control of green peach and potato aphids in leafy vegetables and cole crops can be achieved by a single, at-planting soil application. Through root uptake,

Aphids on Head Lettuce

the compounds provide significant reduction of aphid colonization on winter crops for up to 75 days or more. Furthermore, because they are applied as a liquid in the bed preparation or planting operations, there is no additional application costs associated with their use. This prophylactic approach has been the industry standard since 1993 and has been applied on as much as 80% or the head and leaf lettuce acreage planted annually in the AZ and CA deserts.

The second approach to aphid management in the desert growing areas of is a preventative foliar approach. Fields not planted with imidacloprid are routinely treated with foliar insecticides upon detection of aphid colonization. Foliar sprays should be applied for aphid control based on a simple action threshold; when an average of 10% of plants has aphid colonies (2 or more immature apterous aphids) present. Plants should be sampled 5-7 days following sprays and retreated if the threshold is exceeded again.

Older products such as Orthene (acephate), endosulfan, Metasystox-R, dimethoate, malathion and pyrethroids can provide suppression of aphid populations on lettuce and cole crops with limited residual. Metasystox-R is particularly effective against cabbage aphids. Repeated applications will probably be necessary, depending on time to harvest and aphid pressure. Provado (foliar formulation of imidacloprid) also provides a foliar alternative to Admire. None of these products provides a quick, rapid knockdown of established aphid colonies and their reentry intervals and pre harvest intervals vary, depending on rates and crops. After years of extensive use, many of these compounds only provide marginal efficacy against green peach aphid, and it is now common for PCAs to tank-mix the older products together or with a pyrethroid to achieve adequate economic control.

In the past few years, several new products have become available that offer good residual control of most aphids species in leafy vegetables and cole crops. These include pymetrozine (Fulfill) that belongs to a new, novel chemistry know as the pyridine azomethines. A highly selective, anti-feeding compound, it is slow acting, but has both contact and systemic activity on aphids. Acetamiprid (Assail) and thiamthoxam (Actara) are two new reduced-risk insecticides that are second-generation neonicotinoids with contact and translaminar activity via foliar applications. Another product is flonicamid (Beleaf), a translaminar insecticide that is a quick acting compound that immediately suppresses the feeding of aphids It is non-toxic to beneficial insects, and has an excellent toxicology profile. These compounds can be slow acting during cooler weather conditions (3-7 days) and are not capable of controlling heavy aphid infestations within heads and other protected leaf areas on leafy vegetable crops. Most recently, a new insecticide spirotetramat (Movento) has been developed that provided systemic activity against aphids as a foliar spray. Like the other new compounds it is slow acting (7 d) under cooler weather and has shown excellent activity against lettuce and foxglove aphids when applied during early colonization. The same approaches are appropriate for management of aphids in melons. No action thresholds have been developed but foliar sprays should be applied when aphids are found colonizing leaves and causing leaf to curl downward.

Aphids on Lettuce

Alternatives for Aphid Control at Specific Lettuce Crop Stages

Insecticide	IRAC MOA	Pre - plant Soil	Stand establishment		Thinning to Heading				Heading to Harvest		
			Coty-1 leaf	2-4 leaf	5-8 leaf	9-15 leaf	15-20 leaf	Pre - head	Early heading	2-5" head	4-6" head
Imidacloprid	4A										
Provado	4A		•	•	•	•	•	•			
Platinum	4A										
Actara	4A		•	•	•	•	•	•	•	•	
Assail	4A		•	•	•	•	•	•	•	•	
Endosulfan	2A		•	•	•	•	•	•	•	•	
Orthene	1B		•	•	•						
MSR	1B		•	•	•						
Capture	3		•	•	•	•	•	•	•	•	•
Fulfill	9B		•	•	•	•	•	•	•	•	
Beleaf	9C		•	•	•	•	•	•	•	•	•
Movento	23										•

Aphids on Broccoli

Alternatives for Aphid Control at Specific Broccoli Crop Stages

Insecticide	IRAC MOA	Pre-plant Soil	Stand establishment		Thinning to Heading				Heading to Harvest		
			Coty-1 leaf	2-4 leaf	5-10 leaf	10-15 leaf	15-20 leaf	20-25 leaf	Early button	2-4" head	4-6" head
Admire/ Provado	4A		•	•	•	•	•	•			
Platinum/ Actara	4A		•	•	•	•	•	•	•	•	
Assail	4A		•	•	•	•	•	•	•	•	
Endosulfan	2A		•	•	•	•	•	•	•	•	•
MSR	1B		•	•	•	•	•	•			
Capture	3		•	•	•	•	•	•	•	•	•
Fulfill	9B		•	•	•	•	•	•	•	•	
Beleaf	9C		•	•	•	•	•	•	•	•	
Movento	23										•

- • to be used in combination with a different IRAC mode of action

Always consult the label before applying any pesticides

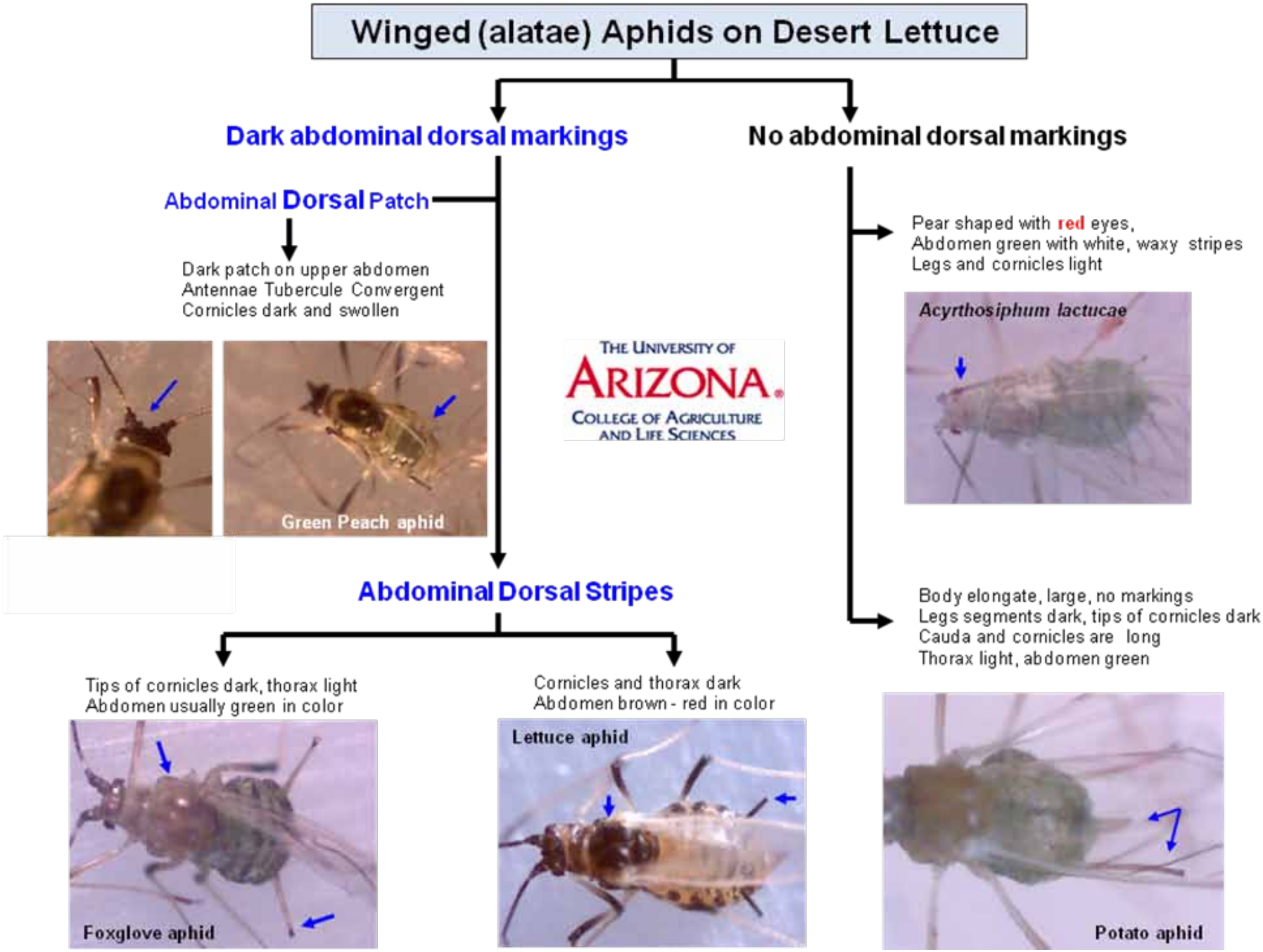

Plate 1. Pictorial Key for the Five major aphid species found in lettuce (alate forms)

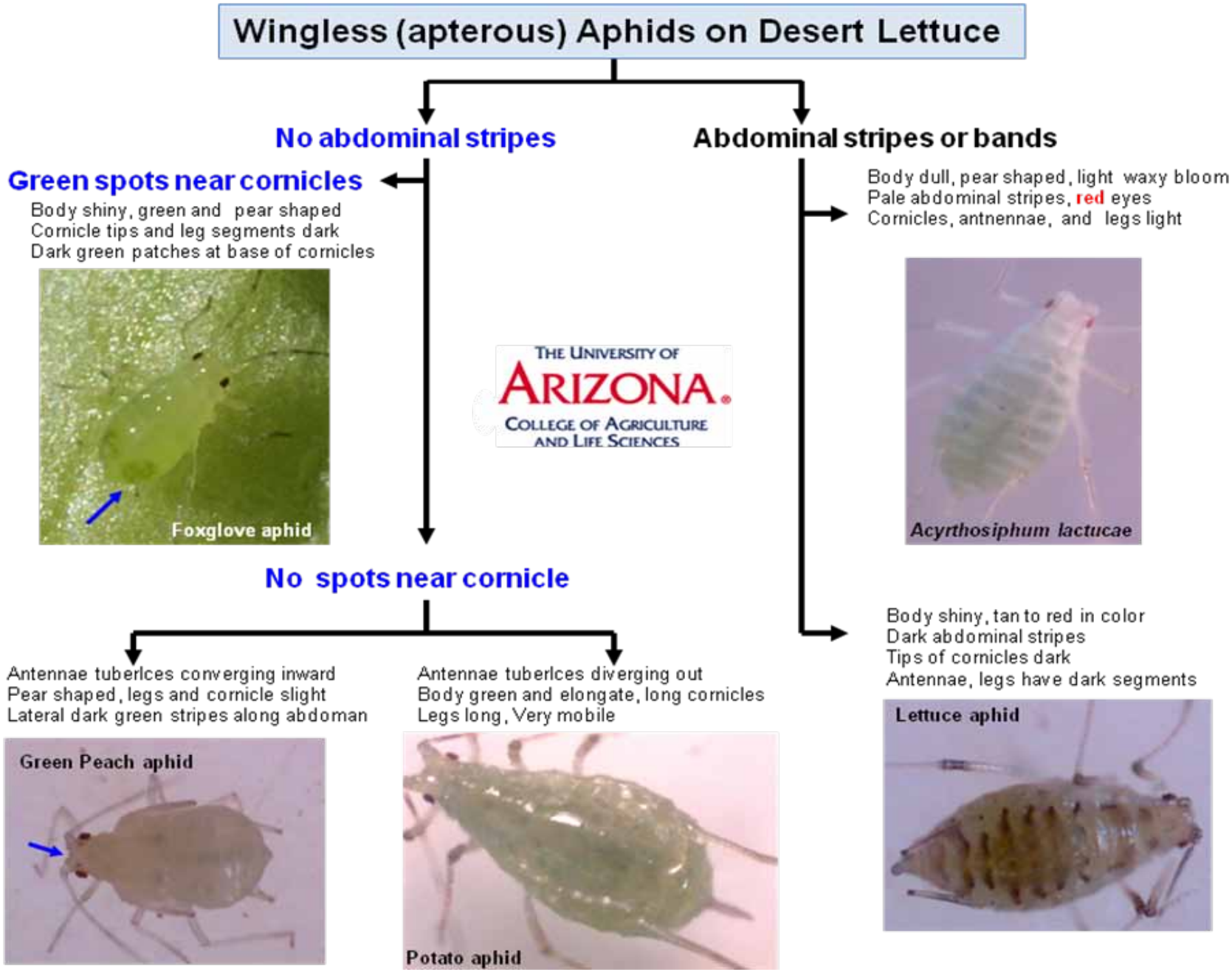

Plate 2. Pictorial Key for the Five major aphid species found in lettuce (apterous forms)

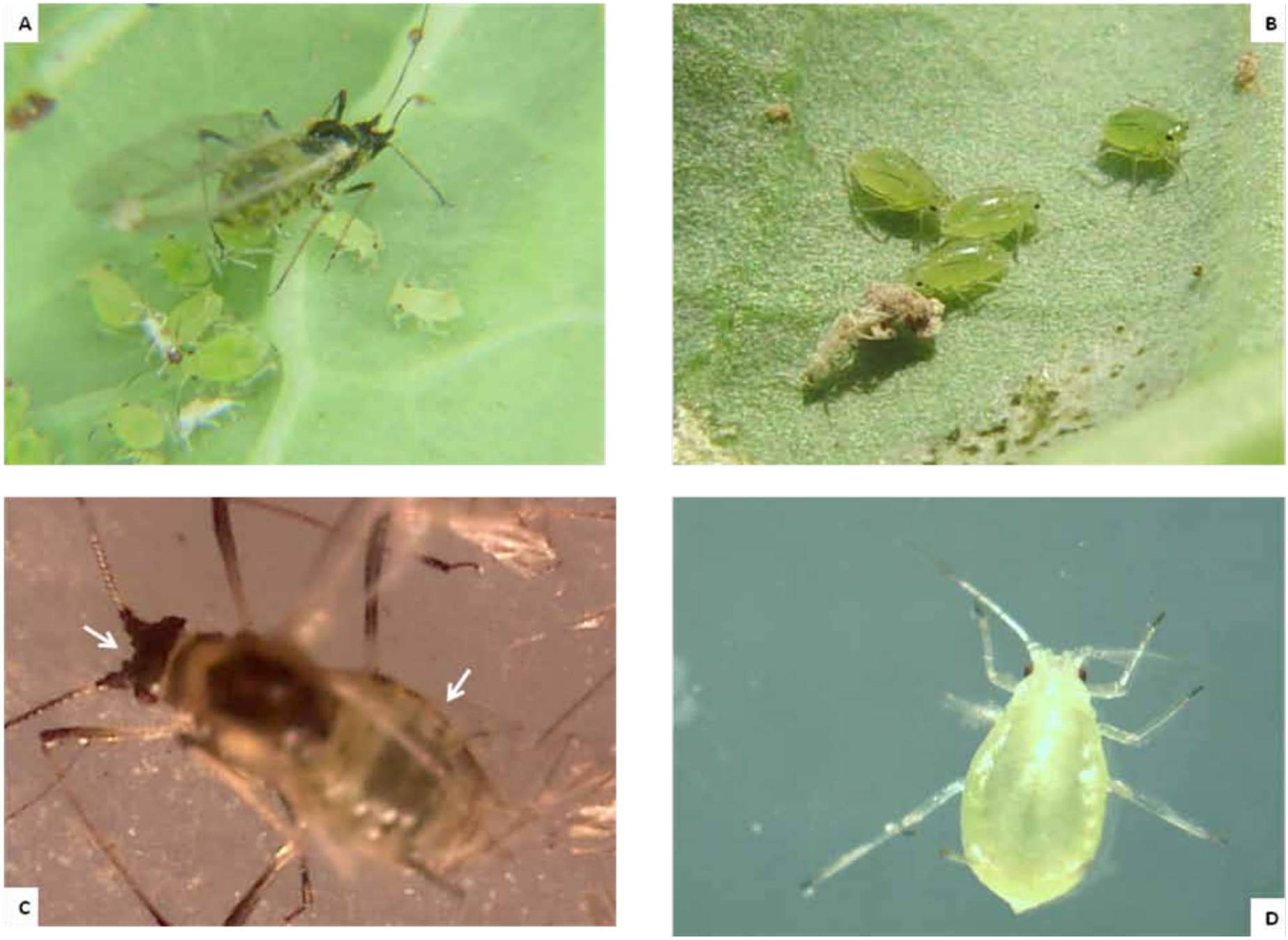

Plate 3. A) Green Peach Aphid (GPA) mature alate and immatures on lettuce, B) GPA apterous nymphs on lettuce on broccoli, C) GPA alate; note the converging antennal tubercles and dark patch on abdomen, D) GPA apterous form; note the converging antennal tubercles

Plate 4. A) Potato Aphid (PA) mature alate, B) Mature PA apterous nymph, C) PA Alate; note the light thorax and long cornicles, D) PA apterous form; note the long cornicles and cauda terous; note red eyes and light cornicles

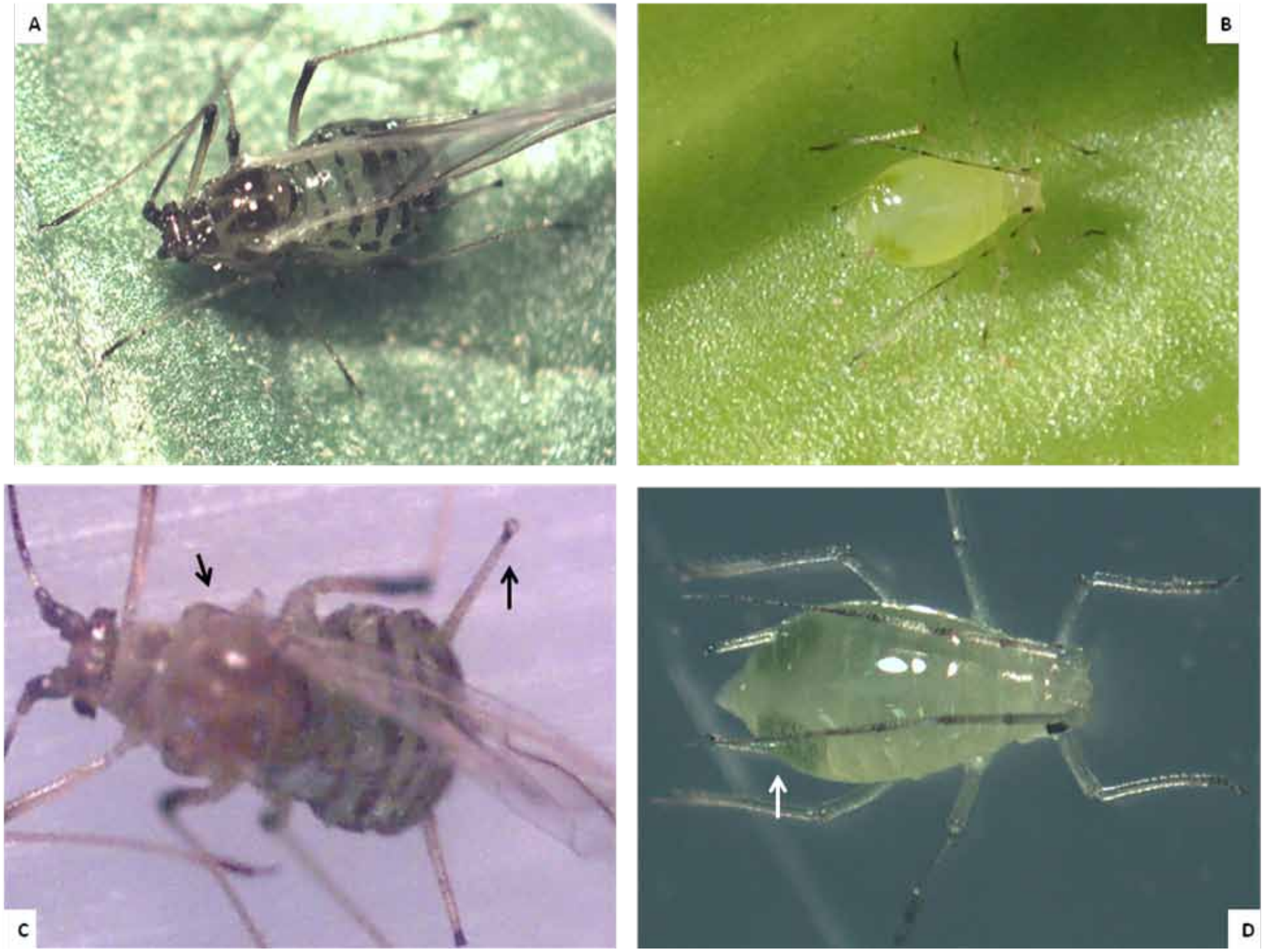

Plate 5. A) Foxglove Aphid (FGA) mature alate, B) Mature FGA apterous nymph, C) FGA Alate; note the light thorax and dark tips on cornicles, D) FGA apterous form; note dark patches at base of cornicles

Plate 6. A) Lettuce Aphid (FGA) mature alate, B) Mature LA apterous nymph, B) LA Alate; note the dark thorax and cornicles, D) FGA apterous immature forms; note the red color of abdoman and throax

Plate 7. A) GPA colonizing spinch leaf , B) FGA apterous form on celery stalk, C) FGA and GPA on celery leaf, D) Melon aphid apterous forms on celery leaf

Plate 8. A) Cabbage aphids apterous forms on seed pods of broccoli seed crop, B) Damage to broccoli seed crops by cabbage aphid, C) Turnip aphid apterous forms on cauliflower leaf, D) Turnip Aphid colonizing cauliflower plant