THE TIGER BEETLES OF ALBERTA (COLEOPTERA: CARABIDAE, CICINDELINI)[1]

Gerald J. Hilchie
Department of Entomology
University of Alberta
Edmonton, Alberta T6G 2E3.

Quaestiones Entomologicae
21: 319-347 1985

ABSTRACT

In Alberta there are 19 species of tiger beetles (*Cicindela*). These are found in a wide variety of habitats from sand dunes and riverbanks to construction sites. Each species has a unique distribution resulting from complex interactions of adult site selection, life history, competition, predation and historical factors. Post-pleistocene dispersal of tiger beetles into Alberta came predominantly from the south with a few species entering Alberta from the north and west.

INTRODUCTION

Wallis (1961) recognized 26 species of *Cicindela* in Canada, of which 19 occur in Alberta. Most species of tiger beetle in North America are polytypic but, in Alberta most are represented by a single subspecies. Two species are represented each by two subspecies and two others hybridize and might better be described as a single species with distinct subspecies. When a single subspecies is present in the province morphs normally attributed to other subspecies may also be present, in which case the most common morph (over 80% of a population) is used for subspecies designation.

Tiger beetles have always been popular with collectors. Bright colours and quick flight make these beetles a sporting and delightful challenge to collect.

The purpose of this paper is to provide a guide to the tiger beetles occurring in the province of Alberta. Information on life history, species recognition, habitat preference, collecting sites and a brief synopsis of biogeographical considerations for interpretation of present distribution patterns have been included.

LIFE HISTORY

Adults

Tiger beetles are capable fliers and quick on their legs, being able to escape rapidly when disturbed. Most tiger beetles are diurnal, preferring bright sun, but, some are active at night. Adults of one species in Alberta, *Cicindela lepida*, are normally active during the day, but, on warm nights, they will resume hunting activities shortly after sunset. Most tiger beetles at the onset of night or inclement weather dig shallow burrows for refuge.

Alberta *Cicindela* can also be divided into two categories based on the life span of the adult: those species having long lived adults which overwinter (spring-fall) and those in which adults

---

[1]Portions of the text were published in Alberta Naturalist 14: 105-111, 1984. Tiger Beetles of Alberta- life history and key.

live for a single summer (summer). In spring-fall species, adults freshly emerged from pupae prepare for winter in late summer or early autumn by excavating a deep burrow. Wintering quarters vary in depth, depending on the species and the nature of the soil. *Cicindela repanda* adults for example will dig burrows 15 to 21 cm deep in clay soils and up to 56 cm deep in sandy soils, while those of *C. formosa* have been recorded digging burrows down to 109 cm in sand (Criddle 1907).

Spring-fall-adults are sexually immature in the fall (Willis 1967) and appear to need winter chilling to break reproductive diapause. Wintered adults lay eggs the following spring.

Summer-adults do not diapause and are reproductively active within days of emerging from the pupa.

Tiger beetles can be grouped ecologically. In Alberta, adults of species found along streams tend to have dark elytra with well defined maculations (*C. repanda*, *C. hirticollis*, *C. duodecimguttata*, *C. oregona*), those found on dark soils often have reduced maculation and are black (*C. nebraskana*, *C. purpurea purpurea*, *C. longilabris*), those found along margins of sand dunes tend to be brightly coloured (*C. formosa formosa*, *C. lengi*, *C. scutellaris*) and those found in the open on drifting sand are very pale and blend in with the sand (*C. limbata nympha*, *C. lepida*, *C. formosa gibsoni*).

Food for adults consists of other insects. Almost any insect will be taken with the exception of certain bugs and of prey too large or small to handle. Large tiger beetles will prey opportunistically on members of other smaller species.

There are few effective predators of tiger beetles. Dragon flies and robber flies have been observed catching tiger beetles in flight (Graves 1962, Lavingne 1972) and birds occasionally prey on them. For example, droppings of Ringbilled Gulls (at Gull Lake, Alberta) contained pieces of elytra from *C. repanda C. hirticollis* (personal observation, 1973). Normally the quick movements, rapid flight and cryptic colouration of tiger beetles make their capture by people and other predators difficult.

Eggs and Larvae

Eggs are deposited in spring through summer, depending on species. The female makes a small hole in the ground with her ovipositor and deposits a single egg. The egg hatches a few weeks later into a first instar larva. This larva first enlarges its hole and then positions its head and thorax at the burrow entrance and waits for its first meal (Fig. 1). If prey is readily available, feeding will last for a few weeks, then the larva plugs its burrow entrance and remains dormant until late summer. Feeding then resumes for a few weeks or until the onset of cold weather. The larva diapauses until spring at which time feeding resumes (Hamilton 1925, Willis 1967).

Depending on the species, larvae may reach maturity (third instar), pupate and emerge as adults by the end of June (summer-adult species). Alternatively, larvae may stop feeding during mid-summer, resume feeding in late summer, then pupate and emerge as adults in late August or early September (spring-fall-adult species). In all species at least one larval instar passes through winter, but only in spring-fall species do adults survive a winter (Criddle 1907, 1910, Hamilton 1925, Shelford 1908, Willis 1967).

Tiger beetle larvae, like adults, are carnivorous. Large mandibles provide an effective means of subduing prey (Fig. 2). Larvae of *C. formosa* may dig a pit at the burrow entrance, that may be used to trap ants and other small insects (Criddle 1910). Larvae of most species do not dig a trap but lunge and seize prey near the burrow entrance. Prey is pulled into the burrow and the larva then consumes it in relative safety. Strong abdominal spines anchor the larva to the burrow wall (Fig. 1) preventing accidental dislodgement by large prey. If the prey is too large, the larva releases the would be victim and retreats by dropping to safety at the bottom of its burrow.

Larval burrows vary in depth according to species, soil type and larval age. Depths range from a few cm for larvae of *Cicindela repanda* and *C. duodecimguttata* along stream margins to depths in excess of 3 m for those of *C. lepida* and *C. formosa* on sand dunes.

Few predators attack tiger beetle larva. Some Beeflies (*Anthrax* spp., Bombiliidae) lay eggs near burrow entrances. The hatching fly maggot may then locate and parasitize the tiger beetle larva. Parasitized larvae fail to complete development, dying during or just before pupation. Swan (1975) found up to 7% of a population of *Cicindela scutellaris* larvae to be parasitized.

Other larval parasites are members of the tiphiid wasp genus *Methocha* Latreille. These small wingless wasps wander in areas occupied by tiger beetle larvae. When siezed, the wasp immediately stings the beetle larva in the soft gular cuticle under its head, causing temporary paralysis; an egg is then deposited and the wasp wanders off to be grabbed by another victim. The narrow, elongate shape and armored cuticle of the wasp prevents it from being pierced by the larva's mandibles and allow the wasp to manoeuvre and sting the larva. The wasp larva hatches and remains attached as an external parasitoid. When the host larva pupates, the wasp larva then begins to actively feed, consuming and killing the pupa from inside out.

Pupae

Pupation occurs in a specially prepared chamber opening into the side of the larval burrow. In summer-adult species, the larvae feed in spring before molting into pupae. The larvae of spring-fall adult species feed for an extended period in the spring and may feed in late summer before molting into pupae (August). Pupation lasts for a few weeks. Summer-adult species emerge as adults in late June and early July, while spring-fall-adult species emerge as adults in late August through early September. The spring-fall-adults feed for a short time before entering winter diapause, with breeding occurring the following spring.

Possible factors influencing selection for summer or spring-fall species

Maintainence of summer and spring-fall species involves a combination of past- and presently acting selective pressures. Habitat, an obvious feature, may at first glance be implicated as a factor influencing life history. However, the four summer species in Alberta occupy different habitats. Members of *C. lepida* live on sand dunes, those of *C. nevadica* on alkaline soil, those of *C. punctulata* on gravelly prairie soil and those of *C. terricola* on clay or dark loamy grassland soils. Similar diversity of habitats are found in spring-fall species.

Interactions between tiger beetle species appear important. Interspecfic contact may involve competitive interactions for adult hunting sites, food, larval burrow sites, oviposition sites, wintering sites and predation on or by other tiger beetles. For example, the spring-fall species, *C. formosa*, *C. lengi*, *C. scutellaris* and *C. limbata nympha*, and the summer species, *C. lepida* adults share overlapping habitat on the Empress sand dunes of Alberta. Habitat partitioning appears to be expressed as adult hunting sites. Food selection is similar for all species, the beetles feed on any insect of suitable size (see Willis (1967) for diet of saline habitat tiger beetles). Adults of *C. lengi*, *C. lepida* and *C. scutellaris* live in the margins of sand dunes and adjacent grasslands, while those of *C. l. nympha* live in the margins and out onto open sand. Beetles of *C. l. nympha* appear to reduce detrimental interaction (predation) by moving away from dune margins when tiger beetles of other species are present. Temporal partitioning of habitat also effectively reduces intraspecfic interactions for beetles of *C. lepida*. Adults of *C. lepida* occupy the same habitat as those of *C. l. nympha*, but at a different time of year, mid July versus May, June and August. This temporal isolation effectively removes these beetles from direct competition for food and predation with larger spring-fall tiger beetles. In regions south of Alberta, several summer species may occur in similar habitats, When this occurs additional temporal shifts may occur in population abundance (Willis, 1967).

The other, summer-adult species in Alberta do not appear to have as complex interactions with other tiger beetle species as does *C. lepida*. It is possible that being a summer-adult species has supplied a competitive advantage to members of the species either in the past or in a portion of the species present range. Following post pleistocene dispersal, these interactions may no longer occur in Alberta.

There must also be some advantage to be gained from being a spring-fall species. Upon examining distribution maps, one notices immediatlely that spring-fall species have ranges which extend north into cooler climatic zones. Prolonged larval development with a long feeding period allows for greater success in obtaining adequate nutrition for completion of development. In some spring-fall species, larvae may take several seasons to complete development. Interactions between other tiger beetle species are limited with one or two species occupying similar but not identical habitats.

Each tiger beetle species has its own unique history. Variations do occur, however, with some species not fitting neatly into a defined pattern. Further investigations are required to elucidate precisely what factors are involved in maintaining these two life history types in Alberta.

KEY TO THE TIGER BEETLES OF ALBERTA

This key is adapted from Wallis (1961), Freitag (1965) and Willis (1968). When two subspecies are present in Alberta, information regarding their separate recognition is included. See Fig. 3 for details on nomenclature of elytral maculation. When examining for characters such as presence of microserrations, a magnification of 40X may be required. Most of the other characters can be seen with the unaided eye or with a 10X hand lens.

1 Frons glabrous or with two supraorbital setae (Fig. 6) 2

1′ Head covered with hairs or with clusters of hair on the inner margin of each eye (Fig. 5) 6

2 (1) Elytral apices serrate with a row of blue or green foveae (Fig. 31) . . . . *C. punctulata*, p. 331

2′ Elytra apices not serrulate, without a row of metallic blue to green foveae 3

3 (2) Small beetles, less than 15 mm, labrum short (length parallel to long axis of body less than one half its width) . . . . *C. terricola* 4

Larger beetles, greater than 15 mm, labrum long 5

4 (3) Marginal band complete (Fig. 25) . . . . . . *C. terricola cinctipennis*, p. 332

4′ Marginal band reduced (Fig. 26) . . . . *C. terricola imperfecta*, p. 332

5 (4) Elytra shallowly punctate or sculptured into waves, shiny between punctures or on crests of waves, abdominal sternites dull black (Fig. 9) . . . . *C. nebraskana*, p. 328

5′ Elytra granulate, dull or with slight sheen near base, abdominal sternites metallic green to violet (Fig. 10) . . . . *C. longilabris*, p. 327

6 (1) Head more or less hairy (Fig. 4), at least a few hairs on frons, if abraded punctures mark former location of hair 7

6′ Head with only clusters of hair on anterior inner margin of each eye (Fig. 5) 20

7 (6) Hair on head, thorax and abdomen decumbent 8

7′ Hair more or less erect on at least part of body (beetles killed in liquid may have matted hair), markings usually well defined 11

8 (7) Dark elytral markings not sharply defined, legs pale, on sand dunes (Fig. 32) . . . . *C. lepida*, p. 333

8′ Dark elytral markings more sharply defined, legs dark 9

9 (8) Elytral dark markings reduced, mostly pale (Fig. 13) . . . . *C. limbata nympha*, p. 326

9′ Elytral dark markings not greatly reduced, more typical banding pattern 10

10 (9) Middle band straight and oblique, not "hooked" at end, pale markings heavy, wide (Fig. 12) . . . . *C. limbata hyperborea*, p. 326

10′ Middle band sinous, curved, hooked at end, pale markings not heavy; alkali washes (Fig. 30) . . . . *C. nevadica*, p. 332

11 (7) Marginal line joined or touching humeral lunule 12

11′ Marginal line separated, not touching humeral lunule, often greatly reduced 15

12 (11) Humeral lunule "c" shaped 13

12′ Humeral lunule oblique, pale markings wide 14

13 (12) Genae glabrous (Fig. 7), posterior tip of humeral lunule (when present) with slight anterior hook (marginal line may touch apical lunule, Fig. 11) . . . . *C. hirticollis*, p. 326

13′ Genae setose (if hairs abraded, punctures mark their former position, Fig. 8), marginal line usually separated from apical lunule (Fig. 14) . . . . *C. repanda*, p. 324

14 (12) Length greater than 15 mm, line of humeral lunule obliterated totally or in part by marginal band (Figs. 21 & 22) . . . . *C. formosa*, p. 328

14′ Length less than 15 mm, humeral lunule long, spur may almost touch middle band (Fig. 23) . . . . *C. lengi*, p. 330

15 (11) Marginal line greatly reduced or absent, humeral lunule absent or reduced to spots (Figs. 27, 28 & 29) 16

15′ Marginal line present (Figs. 18, 19 & 20), obvious spur, humeral lunule present 18

16 (15) Middle band wide long, apical end not markedly curved, color green to violet (Fig. 28) . . . . *C. decemnotata*, p. 329

16′ Elytral markings thin, light, middle band more strongly curved, shorter than width of elytron 17

17 (16) Post humeral spot usually absent, middle band widely separated from margin, color green or black (Fig. 27) . . . . *C. purpurea*, p. 328

17′ Post humeral spot usually present, middle band narrowly separated or touching margin, color red or greenish, middle band transverse, often

strongly curved at apical end (Fig. 29) . . . . . *C. splendida limbalis*, p. 329
18 (15) Genae glabrous (Fig. 7), elytra with greasy appearance, pale markings heavy, on alkali soils and washes (Fig. 20) . . . . *C. fulgida*, p. 330
18′ Genae with hairs or or setigerous punctures (Fig. 8) 19
19 (18) Humeral lunule "c" shaped, scape (basal segment) of antenna with few hairs (Fig. 18) . . . . *C. duodecimguttata*, p. 325
19′ Humeral lunule oblique, scape of antenna hairy (more than 10 hairs) (Fig. 19) . . . . *C. tranquebarica*, p. 331
20 (7) Elytra not serrulate, non punctate, in Alberta red/green elytra without pale maculations (Fig. 24) . . . . *C. scutellaris*, p. 330
20′ Elytra punctate, serrulate, color brown, blue, olive, maculations typical to reduced . . . . *C. oregona* 21
21 (20) Pleura of thorax blue/purple, elytra brown, green, blue, maculations narrow, pronotum brown (Fig. 15) . . . . *C. oregona oregona*, p. 325
21′ Thoracic pleura coppery, elytra dark brown, maculations narrow (Fig. 16) . . . . *C. oregona guttifera*, p. 325

TIGER BEETLES OF ALBERTA

1. *Cicindela repanda* Dejean (Figs. 14 & 33)

***C. repanda repanda* Dejean**

Recognition.— (Fig. 14) These beetles resemble members of *C. duodecimguttata*. Separation between them is based on configuration of the marginal band: in *C. repanda* the band is continous or narrowly separated from the humeral lunule (Fig. 14), whereas in *C. duodecimguttata* the band has a wide gap (Fig. 18). For positive identification the male genitalia must be examined (see Freitag (1965) for method). *Cicindela duodecimguttata*, *C. repanda*, *C. hirticollis*, *C. limbata* and *C. oregona* form part of the Maritima group and many species in this group resemble each other.

Habitat.— These beetles inhabit sand, gravel and clay soils with sparse vegetation adjacent to streams and rivers. Adults may be found running near the water over patches of mud. Wintering grounds for the adults may be some distance from their summer haunts. Winter burrows are made in bare dry hillsides (Criddle 1907). Larvae may be found scattered through vegetation near stream or pond margins. This species has a two year life cycle, with the third instar larva passing through the first winter and the adult the second (Hamilton 1925).

Localities.— (Fig. 33) Athabasca River (5 km east, Chain Lakes), Barker Lake, Barrier Reservoir, Brazeau River (near Lodgepole), Calgary, Chin (4.8 km south), Crimson Lake, Clyde (6.5 km east), Deadwood (banks of Peace River), Devon, Dilberry, Drayton Valley, Dunvegan, Edmonton, Empress (11 km south), Fawcett, Flatbush (Pembina River), Fort MacKay, Fort McMurray, Garth, Gem, Gibbons, Green Island (sic!,=Verte Island), Gull Lake, House River, Jenner, Lesser Slave Lake, Little Smoky River, Lethbridge, Medicine Hat, McGrath, Meikle River (Mackenzie Highway), Milk River (junction with Lost River), North Saskatchewan River (near Rocky Mountain House), Patricia (near), Peace River, Pembina River (near Lodgepole), Red Deer, Red Deer River (near Bindloss), Saunders, Smoky River, Wainwright, Wapiti River (south of Grande Prairie).

2. *Cicindela duodecimguttata* Dejean (Figs. 8, 18 & 34)

Recognition.— (Figs. 8 & 18) This species is similar to *C. repanda* but is more closely related to *C. oregona* and hybridizes with it along the Rocky Mountain Foothills of Alberta (Freitag, 1965). Populations of *C. duodecimguttata* occur east of the foothills and populations of *C. oregona* to the west along mountain valleys. Hybrid populations have markings intermediate to those of *C. oregona* and *C. duodecimguttata* (Freitag 1965) (Fig. 17). The humeral lunule may be narrowly broken or expressed as a spot and the marginal line is of variable length.

Habitat.— These beetles live close to pond and stream margins. When in association with *C. repanda*, beetles of *C. duodecimguttata* move away from the water's edge reducing habitat overlap. Adults and larvae winter in burrows 1.2 to 2 m back from the stream or pond margin. If the water rises in spring before beetles are active, large numbers may perish (Criddle 1907). Members of this species have a two year life cycle similar to that of *C. duodecimguttata*.

Localities.— (Fig. 34) Andrew, Beaverhill Lake, Bilby, Brazeau River (near Lodgepole), Calgary, Chin, Clyde (6.5 km east), Cooking Lake, Crimson Lake, Cypress Hills, Doussal, Drayton Valley, Edmonton, Fallea, Flatbush, Fort Chipewyan, Fort McMurray, Fort MacKay, Gull Lake, Happy Valley (Porcupine Hills), Halfwayhouse, Jenner, Lake Cardinal, Lesser Slave Lake, Lethbridge, Louis Bull Reservation, Medicine Hat, North Saskatchewan River (near Rocky Mountain House), Police Lake, Redwater, Saunders, Smith-Fitzgerald Road (km 11), Stirling Lake, Tilley, Tofield, Vilna, Wabamum.

3. *Cicindela oregona* LeConte (Figs. 15, 16 & 35)

***C. oregona oregona* LeConte (Fig. 15)**

***C. oregona guttifera* LeConte (Fig. 16)**

Recognition.— (Figs. 15 & 16) These beetles are distinguished from those of related species by the presence of small groups of hairs on the inner margin of each eye. Markings are similar to those of *C. duodecimguttata* and *C. repanda*. This species hybridizes with *C. duodecimguttata* in the foothill region (Freitag 1965) (see discussion under *C. duodecimguttata*) and in the Northwest Territories.

Wallis (1961) called the Albertan populations *C. oregona guttifera*. On examination of Albertan material I found these beetles to be intermediate between *C. oregona oregona* and *C. oregona guttifera* which agrees with Freitag (1965). Members of the subspecies *guttifera* are characterized by a humeral lobe represented by two large spots, the dorsal surface is more or less olive with a metallic lustre, thoracic pleura are coppery and the ventral surface is bicolored. The elytral spine is small and serrulations of the apex are weak. Representatives of the subspecies *oregona* are similar to *guttifera* but the elytral spine and serrulations are well developed and the thoracic pleura are metallic blue like the ventral surface. Imprecise definition of Albertan populations is due to hybridization of *C. o. oregona* with *C. o. guttifera* and *C. duodecimguttata*. The specimen collected in the Peace River area was clearly *C. o. guttifera*.

Habitat.— Individuals of *Cicindela oregona* live along margins of streams and lakes on clay or sandy soils with little vegetation cover. The habitat may be shared with members of *C. repanda*, *C. duodecimguttata*, and *C. hirticollis*.

Localities.— (Fig. 35) *C. o. oregona* X *C. o. guttifera*: Athabasca Falls, Banff, Carbondale, Castle River, Highwood River, Hillcrest, Kootenay Plains, Laggan (=Lake Louise), New Dayton (1.6 km east), North Saskatchewan River (near Nordegg), Waterton.

C. o. guttifera: Green Island (sic!, = Verte Island).

4. *Cicindela hirticollis* Say (Figs. 11 & 36)

Recognition.— (Fig. 11) Members of this species are distinguished from others of the Maritima group by the strongly "C" shaped humeral lunule on the elytra. In other respects they are similar to members of *C. repanda*.

C. hirticollis is represented by one form throughout most of Canada. Subspecies recognition is based on width of elytral maculations. Most specimens have wide markings and are called *C. h. ponderosa* Thoms. The problem is that, within local populations, many individuals may have narrow maculations and could be assigned to another subspecies. Dull brown elytra are the norm, but, on the Athabasca drainage, some blue beetles have been collected. Due to the wide geographic range and nature of variation I do not feel that assigning the Albertan populations to a particular subspecies is appropriate.

Habitat.— These tiger beetles are found on light colored beach sands with little or no vegetation. The habitat may be shared with other members of the Maritima group. This species appears to have summer-adults.

Localities.— (Fig. 36) Athabasca River, Calgary, Crimson Lake, Dunvegan, Empress, Fort McMurray, Gull Lake, Jasper, Jasper Lake, Lac La Biche, Lesser Slave Lake, Medicine Hat, Red Deer, Red Deer River (near Bindloss), Snaring River (Jasper National Park).

5. *Cicindela limbata* Say (Figs. 4, 12, 13, 37 & 38)

***Cicindela limbata nympha* Casey (Figs. 4, 12 & 37)**

***Cicindela limbata hyperborea* LeConte (Figs. 13 & 38)**

Recognition.— (Figs. 4, 12 & 13) Two subspecies, very different in appearance, occur in Alberta.

Individuals of *Cicindela limbata nympha* are distinguished by the pale elytra with reduced dark markings. The marginal band is expanded to cover most of the elytra leaving a narrow dark band down the centre. A brownband identifies the subspecies *nympha*, a green band *C. l. limbata*. Nearly all of the specimens examined were marked with the brown; hence the Albertan populations are assigned to *C. l. nympha*.

Specimens of *Cicindela limbata hyperborea* do not look like those of the southern subspecies. Instead they resemble other members of the Maritima group of which *C. limbata* is a member. Markings are of typical tiger beetle design with a brown elytral ground color. The greatly thickened elytral bands distinguish members of this subspecies from those of all other Maritima group species found in Alberta.

Habitat.— These beetles prefer sandy blowouts or sand dunes which are sparsely vegetated. When the species is present it is usually very abundant. Adults are known to winter in loose sand. Beetles of *Cicindela limbata nympha* occur on prairie sand dunes and blowouts, whereas those of *C. l. hyperborea* are found in similar habitats in the boreal forest. Individuals of the northern subspecies also occur in disturbed sandy areas along roadways. In Manitoba *C. l. nympha* has a three year life cycle (Criddle 1907, Hamilton 1925).

Localities.— *C. l. nympha*: (Fig. 37) Blindman River, Bruderheim, Calgary, Chauvin, Claysmore, Clyde, Clyde (6.5 km east), Crimson Lake, Czar, Dilberry, Egerton, Edmonton, Empress, Empress (11 km south), Gull Lake, Hondo, Lesser Slave Lake, Nestow, Orion, Opal, Pakowki Lake, Ponoka (5 km south), Red Deer, Ribstone, Rochester, Stauffer, Tawatinaw, Winterburn.

C. l. hyperborea: (Fig. 38) Barber Lake, Fort Chipewyan, Fort MacKay, Fort MacKay (10 km south), Fort Mackay (8.5 km east, north of Athabasca River Bridge), Fort McMurray, Fort Smith (N.W.T., northern border of Alberta), Gregorie Lake.

6. *Cicindela longilabris* Say (Figs. 10 & 39)

***Cicindela longilabris longilabris* Say**

Recognition.— (Fig. 10) This tiger beetle of the foothill and boreal regions is closely related to *C. nebraskana*. Correct identification is often difficult. Species determination is based on microstructure of the elytra and habitat preference when known.

Adults of are characterized by smooth or very slightly waved sculpture on the elytra. The surface is covered with minute granules giving the beetle a dull lustre. If shiny areas do occur, these are small and restricted to the crests of the waves. The lustre may be due to wear on the elytra in older beetles.

Cicindela nebraskana adults have a larger shiny area, giving the elytra more lustre. A series of granulate punctures surrounded by a glossy mesh or well developed series of waves and ridges are characteristic of this species. Members of *Cicindela nebraskana* live in prairie grasslands and of *C. longilabris* in forest clearings and meadows.

In the Alberta foothills, prairie grassland extends along valley bottoms and on southwest-facing hill sides into the mountains in several places (e.g. Bow River Valley, Crowsnest Valley). In these areas the ranges of these two species overlap. Hybridization has not been observed to occur between them. In localities of overlap, they appear to partition the habitat. Individuals of *Cicindela longilabris* stay near clearings on sandy soils with conifer trees and of *C. nebraskana* on clay soils of the valley grasslands.

Hatch (1953) did not recognize *C. montana* LeConte (=*C. nebraskana*) as a valid species but rather as a variation (abberation) of *C. longilabris*. My experience with these species indicates that they are morphologically very similar but can be distinguished and that they have different habitat preferences. Populations of *C. longilabris* in Alberta are composed primarily of black beetles, with slender feeble markings, hence assignment to the subspecies *C. longilabris longilabris*. However, there are individuals of other phenotypes present. Beetles with heavy markings and a bronzed color are of the *laurenti* Schaupp phenotype, and those with slender markings with a vivid green are of the *perviridis* Schaupp phenotype.

Habitat.— *Cicindela longilabris* adults prefer sandy areas such as ridges and blowouts in conifer forests. Adults are found along sandy forest paths and road sides, and over winter.

Localities.— (Fig. 39) Banff, Barber Lake, Barrier Reservoir, Beaverlodge, Beauvallon, Calling River Ranger Station, Canmore, Cline River, Crimson Lake, Coleman, Crownest Lake, Drayton Valley, Edmonton, Exshaw, Fairview (10 km southeast), Fedora, Fortress Mountain, Fort MacKay, Fort MacKay (8.5 km east, north of Athabasca River Bridge), Fort McMurray (22.4 km north), George Lake, Gorge Creek, Green Island (sic!, =Verte Island), Hargwen, Hinton, Kananaskis Lakes, Kootenay Plains, Marlboro, Millarville, North Saskatchewan River (near Nordegg), Opal, Peace River, Pembina River (near Fawcett), Poachers Landing (Tp.69 Rge.19 W.4), Prairie Bluff Mountain, Robb, Rocky Mountain House, Sand Hill Lake, Saunders, Waterton, Wapiti River (south of Grande Prairie), Whirlpool River, Winterburn.

7. *Cicindela nebraskana* LeConte (Figs. 6, 9 & 40)

***Cicindela nebraskana nebraskana* LeConte**

Recognition.— (Fig 6 & 9) Adults of this species are slightly smaller than those of *C. longilabris* and have reduced elytral maculations. Ground color of the elytra is black to slightly bronzed. Features for separating specimens of *C. nebraskana* from those of *C. longilabris* are discussed under *C. longilabris*.

The Alberta subspecies is *C. nebraskana nebraskana*. Many subspecfic names have been created to describe minor differences in various populations. In Alberta the beetles examined were within the normal range of variation for the subspecies *nebraskana*. These are smooth black to slightly bronzed beetles from prairie grasslands.

Habitat.— These beetles prefer open bare areas between clumps of grass and earth mounds made by ground squirrels. *Cicindela nebraskana* occurs throughout the prairie grasslands on heavy clay soils, and overwinter as adults.

Localities.— (Fig. 40) Barrier Reservoir, Calgary, Carbondale River (junction of Lost Creek), Chin (5 km south), Coronation, Del Bonita, Dorothy, Drumheller, Evans-Thomas Creek, Empress (11 km south), Exshaw, Kananaskis River (Ribbon Creek), Frank, Gorge Creek, Ghost Dam, Highwood River, Hilda, Jenner, Lethbridge, Manyberries, Medicine Hat, Milk River (16 km north of Aden), Milk River (junction with Lost River), Oyen (4.8 km south), Pincher, Porcupine Hills, Prairie Bluff Mountain, Scandia, Seebe, Strathmore, Standard, Stettler, Steveville, Taber.

8. *Cicindela formosa* Say (Figs. 21 & 41)

***Cicindela formosa formosa* Say**

Recognition.— (Fig. 21) This is the largest of the Albertan tiger beetles. The shape of the humeral lunule is distincitive. Superficially, adults of *C. formosa* resemble adults of *C. lengi*. In Alberta the species is represented by the typical subspecies *C. formosa formosa*. Adults have a bright metallic lustre on the ventral surface, with the pigmented areas of the elytra red to red-purple.

Another subspecies, *C. formosa gibsoni* Brown (Figs. 22 & 42), occurs a few kilometers east of the Alberta boundary, in the Great Sand Hills of Saskatchewan. Characteristics of these beetles are: a metallic venter and reduced elytral pigmentation with the marginal band expanded to cover most of the elytra. This subspecies should be watched for in sandy areas near the Saskatchewan boundary.

Habitat.— Beetles of *Cicindela formosa* inhabit sandy blowouts and marginal areas of active sand dunes in areas of sparse vegetation. Adults spend the winter in deep burrows dug into the side of sand dunes. The beetles are sometimes slow to appear in spring because of the slow warming of deeper sand.

Localities.— (Fig. 41) Empress, Empress (11 km south), Fort Macleod, Gem, Medicine Hat, Sandy Point, South Saskatchewan River (junction with Red Deer River).

9. *Cicindela purpurea* LeConte (Figs. 27 & 43)

***Cicindela purpurea purpurea X C. p. audubonni* LeConte**

Recognition.— (Fig. 27) Beetles of this species come in two color forms, black or green. In Alberta most specimens lack the subhumeral spot, and this readily distinguishes them from adults of *C. splendida limbalis*

The name *C. purpurea purpurea* refers to populations of black beetles, and *C. purpurea auduboni* to populations of green beetles. Populations in Alberta are similar to those across the Great Plains, being comprised of a mixture of green and black beetles. Subspecies designation is normally written as *C. p. purpurea X auduboni* to reflect the mixture of forms. The subspecies in Alberta is *C. p. purpurea X auduboni*.

Habitat.— These beetles are found on patches of bare clay soil interspersed with clumps of grass and other plants. This habitat occurs frequently in prairie grasslands. *Cicindela purpurea* winters as an adult. Members of this spring-fall species require at least two years for larval development.

Localities.— (Fig. 43) Aden, Bassano, Brooks, Burdett, Calgary, Castor, Cessford, Cypress Hills, Dillberry, Edmonton, Empress (11 km south), Etzikom, Fort Macleod, Ghost River, Gleichen, Hanna, Hussar, Jenner, Lethbridge, Lost River (5 km north, junction with Milk River), Magrath, Manyberries, Medicine Hat, Merid, Milk River, Orion, Pincher Creek, Ross Creek, Taber, Tilly, Walling.

10. *Cicindela splendida* Hentz (Figs. 29 & 44)
***Cicindela splendida limbalis* Klug**

Recognition.— (Fig. 29) Elytral maculations of these beetles are similar to those of adult *C. purpurea*. The reddish tinge and presence of a subhumeral spot on the elytra serve as distinguishing features. Wallis (1961) considered *limbalis* as a separate species, without distinct forms. Johnson (in prep.) includes *limbalis* as a subspecies of *Cicindela splendida*. Beetles of the *limbalis* phenotype are characterized by a coppery to brown head and prothorax with moderately wide elytral maculations. The *denverensis* phenotype is characterized by blue-green colors and more variable elytral maculations. In Alberta, beetles with coppery greenish to coppery brown colors occur. Johnson considers these beetles to be a blend of *limbalis* and *denverensis* phenotypes. The majority of specimens in Alberta can be assigned to the *limbalis* phenotype, hence the subspecies designation, *C. splendida limbalis*.

Habitat.— These beetles prefer steep clay banks for breeding purposes but adults may be found almost anywhere. I have collected them in the reedy margin of a slough in Calgary. The usual habitat is on bare clay banks of streams. These beetles have a two year life cycle with overwintering adults.

Localities.— (Fig. 44) Bilby, Brocket, Calgary, Calling River Ranger Station, Devon, Edmonton, Elk Island National Park, Fairview, Fawcett, Fort MacKay, Fort McMurray, Fox Creek, George Lake, Gleichen, Golden Spike, Grande Prairie, Happy Valley (Porcupine Hills), Heatherdown, Lausand, Leduc, Nestow, Nevis, Pembina River, Pincher, Pincher Creek, Pouce Coupe (B.C., east in Alberta), Prairie Bluff Mountain, Red Deer, Redwater, Stauffer, Smoky Lake, Stettler, Sundance, Trochu, Wabamum, Wapiti River (south of Grande Prairie), Wetaskwin.

11. *Cicindela decemnotata* Klug (Figs. 28 & 45)

Recognition.— (Fig. 28) This green or violaceous tiger beetle is characterized by reduction of the humeral lunule and a long, descending arm of the middle band of the elytron. There are no recognized subspecies.

Notes.— The violet form of this species is common in the Peace River district and a population of this beetle occurs in grasslands surrounding Whitehorse, Yukon Territory. Adults of this species should be watched for in grassland areas along northern rivers.

Habitat.— These beetles occur on clay, sandy, or gravel soils often along cowpaths and roads. Adults are frequently captured on clay alluvium in badlands and are known to overwinter.

Localities.— (Fig. 45) Deadwood, Dorothy, Drumheller, Empress (11 km south), Fairview (16 km southeast), Fort Macleod, Green Island (sic!, = Verte Island), Happy Valley (Porcupine Hills), Lethbridge, Lost River (5 km north, junction with Milk River), Manyberries (8 km south), Manyberries (32 km south), Majestic, Medicine Hat, Milk River (junction with Lost River), Onefour, Peace River, Pincher, Taber.

12. *Cicindela fulgida* Say (Figs. 7, 20 & 46)

***Cicindela fulgida fulgida* Say**

Recognition.— (Figs. 7 & 20) These beetles differ from all other Albertan cicindelids in their heavy maculation pattern and greasy appearance. Adults of the subspecies *C. fulgida fulgida* are 12 mm in length and have a brilliant coppery to coppery green lustre. The humeral lunule is widely separated from the middle band at its tip.

Habitat.— Members of this species occur on alkaline soils along streams, badlands, coulees and some sloughs on the prairies. Adults are found in areas devoid of vegetation. Beetles can be collected early in spring and late in fall, implying a wintering adult.

Localities.— (Fig. 46) Chappice Lake, Grassy Lake (2.5 km south), Jenner Ferry (now Jenner Bridge), Onefour, Lost River, Medicine Hat, Sandy Point.

13. *Cicindela scutellaris* Say (Figs. 5, 24 & 47)

***Cicindela scutellaris scutellaris* Say**

Recognition.— (Figs. 5 & 24) Adults of this species cannot be mistaken for those of any other species of Albertan tiger beetle. Bright red elytra lacking all maculations characterize this species in Alberta. Subspecies recognition is also based on absence of maculations and on bright red color; other subspecies have reduced maculations along the elytral margins.

Habitat.— Beetles of *Cicindela scutellaris* occur on blowouts and sand dunes in southern Alberta and inhabit the sparsely vegetated edge zone dominated by Scurf Pea (*Psorealea lanceolata* Pursh). The sand dune habitat is shared in part with representatives of *Cicindela formosa*, *C. lengi* and *C. limbata nympha*. Adults overwinter.

Localities.— (Fig. 47) Chappice Lake, Drumheller, Empress, Empress (11 km south), Medicine Hat.

14. *Cicindela lengi* Horn (Figs. 23 & 48)

***Cicindela lengi versuta* Casey**

Recognition.— (Fig. 23) Adults of this species appear similar to those of *Cicindela formosa* but are distinguished by their smaller size, and long, straight humeral lunule. Most Albertan specimens have a reddish elytral ground color. A few beetles examined were green and one was bright metallic blue. Since the majority of specimens have reddish elytra and coppery thoracic sclerites the subspecfic name *C. l. versuta* applies. The name *C. l. lengi* refers to blue to blue-green populations. Other color variations also occur; a deep purple specimen was taken at Opal and Wallis(1961) reported a black specimen from Saskatchewan.

Habitat.— Members of this species inhabit dry open sandy areas in the grasslands of Alberta and may be found on prairie sand dunes and boreal forest sand ridges. These spring-fall beetles may take up to three years to complete larval development. Adults winter in burrows dug in sandy soil.

Localities.— (Fig. 48) Barber Lake, Blackfalds, Chappice Lake, Claysmore, Clyde (6.5 km east), Edgerton, Edmonton, Empress, Empress (11 km south), Fort Macleod, Milk River (16 km north of Aden), Milk River (junction of Lost River), Opal, Pakowki Lake, Rolling Hills, Sand Hill Lake, Writing on Stone Provincial Park (32 km east).

15. *Cicindela tranquebarica* Herbst (Figs. 19 & 49)

***Cicindela tranquebarica kirbyi* LeConte**

Recognition.— (Fig. 19) The long, obliquely-directed, descending arm of the humeral lunule is a distinguishing character. *Cicindela tranquebarica* is common and widespread.

Geographical variation in *C. tranquebarica* is complex and poorly known. Many names have been given to local varieties. The dominant phenotype found in Alberta is that of *C. t. kirbyi* LeConte. The markings are broad with a bronzy-green ground color. North of Alberta, adults of *C. t. borealis* Harrington, can be recognized by a broken humeral lunule band or by the ends of the band narrowly joined in the middle. I have not seen material from Alberta representing the *borealis* phenotype. However specimens from north of Wandering River had reduced band widths although further north, at Fort MacKay, elytral band widths reverted back to the wide state. Specimens of *Cicindela tranquebarica borealis* should be watched for in northern Alberta.

Habitat.— Representatives of this species occur in almost any tiger beetle habitat, ranging from alkaline mud flats, sandy blowouts, and prairie grasslands to boreal forest trails. Disturbed areas are readily colonized. Areas with reduced vegetation cover are preferred. These beetles overwinter as adults.

Localities.— (Fig. 49) Aden (16 km west), Barber Lake, Barnwell, Barons, Bilby, Brazeau River (near Lodgepole), Calgary, Calling Lake Ranger Station, Castor, Chappice Lake, Chin, Claresholm, Clyde (6.5 km east), Clyde (10 km north), Clymont, Consort, Crimson Lake, Deadwood, Drayton Valley, Drumheller, Dunvegan, Edmonton, Empress (11 km south), Fairview (16 km southeast), Fawcett, Fort MacKay, Fort Macleod, Fort McMurray (22.4 km north), Garth, Golden Spike, Gorge Creek, Grande Prairie, Gull Lake, High River, Jenner, Jenner Ferry (Jenner Bridge), Kootenay Plains, Lac La Biche, Lake Cardinal, Lethbridge, Lethbridge (8 km south), Lesser Slave Lake, Lundbreck, Medicine Hat, Milk River (junction of Lost River), Nanton, Nestow, New Dayton (1.6 km east), North Saskatchewan River (near Nordegg), Opal, Peace River, Pincher, Police Lake, Ranfurly, Red Deer, Rosedale, Sand Hill Lake, Smoky River, Snaring River (Jasper National Park), Saint Mary's Reservoir, Simpson, Soda Lake, Stavely, Stauffer, Tofield, Vilna, Wandering River (64 km north), Wetaskiwin, Winterburn, Writing on Stone Provincial Park (32 km east).

16. *Cicindela punctulata* Oliver (Figs. 31 & 50)

***Cicindela punctulata punctulata* Oliver**

Recognition.— (Fig. 31) Adults of *Cicindela punctulata* are readily distinguished by a row of metallic blue or green dots running down the length of each elytron. The other elytral maculations are quite variable, ranging from immaculate to well marked. Usually the maculations consist of a few white spots. *Cicindela puntulata punctulata* is the only known subspecies occurring in Canada.

Habitat.— *Cicindela punctulata* occurs in the southern prairie regions. Thin grass with bare patches of sandy loam is preferred. Adults survive a single summer with the larvae being the only wintering stage. Members of this species are reported to have a one year life cycle (Shelford 1908), however Hamilton (1925) speculated that it took two years to reach maturity.

Localities.— (Fig. 50) Bassano (junction of Highways 1 & 550), Burdett, Comrey, Empress (11 km south), Grassy Lake, Happy Valley (Porcupine Hills), Jenner, Lethbridge, Medicine Hat.

17. *Cicindela terricola* Say (Figs. 25, 26, 51 & 52)

***Cicindela terricola cinctipennis* LeConte (Figs. 25 & 51)**

***Cicindela terricola imperfecta* LeConte (Figs. 26 & 52)**

Recognition.— (Figs. 25 & 26) Adults of *Cicindela terricola cinctipennis* are small slender beetles with an unbroken marginal band. The middle band of the elytra may be distinct or reduced.

Adults of *Cicindela terricola imperfecta* are slightly larger. The marginal band is greatly reduced or at most the humeral lunule is represented by a small spur which joins up with the middle band.

Notes.— Some believe that these subspecies should be elevated to full species status. This recognition is supported by their distinct appearance, habitat preference and geographic distribution.

Cicindela terricola imperfecta ranges through British Columbia into western Alberta, on the Kootenay Plains near Nordegg. *C. oregona* (also primarily found in B.C.) is found here as well. To the west of the plains are low mountain passes into British Columbia. It appears that individuals of this subspecies dispersed eastward over the mountains along river valleys into Alberta, colonizing the grasslands of Kootenay Plains. To the east, extensive montane forest appears to have prevented further dispersal onto the prairies. Specimens of *Cicindela terricola imperfecta* should be watched for in other mountain grasslands along the foothills. It would be very informative if mixed populations of *C. t. imperfecta* and *C. t. cinctipennis* could be found. This would help in determining the species or subspecies status of the two forms.

Adults of *Cicindela terricola cinctipennis* have been taken in the grasslands around Whitehorse, Yukon Territory. This species should be watched for in all native grassland areas in Alberta.

Habitat.— Adults of *Cicindela terricola cinctipennis* prefer sparse grass on clay soils in the prairie grasslands. Wallis (1961) reported that these beetles may also be found on saline and alkaline soils with sparse vegetation. Adults of *C. t. imperfecta* have been taken on sandy clay soils on river banks, the type of habitat on which the beetles were captured at Kootenay Plains (Ball, pers. com. 1975). Adults of both subspecies are active during midsummer.

Localities.— *Cicindela terricola cinctipennis*: (Fig. 51) Calgary, Dorothy, Drumheller, Dunvegan, Empress, Fairview (16 km southeast), Fort Macleod (junction Highways 1 & 2), Green Island (sic!=Verte Island), Hussar, Jenner, Lethbridge, Manyberries, Medicine Hat, Milk River (junction of Lost River), Munson, Patricia (near), Redcliff.

Cicindela terricola imperfecta: (Fig. 52) Kootenay Plains.

18. *Cicindela nevadica* Leconte (Figs. 30 & 53)

***Cicindela nevadica knausi* Leng**

Recognition.— (Fig. 30) These tiger beetles resemble those of *C. cuprescens*, a nonresident species. Adults of *Cicindela nevadica knausi* are bronze with off-white elytral maculations. The humeral lunule is slightly recurved toward the base and body hairs are decumbent. Only one subspecies is known from Canada, *C. n. knausi*.

Habitat.— These beetles may be found along margins of streams and lakes on alkaline soil. Adults prefer open areas with sparse vegetation and are active during midsummer.

Localities.— (Fig. 53) Jenner Ferry (Jenner Bridge), Lost River (near junction with Milk River), Sandy Point.

19. *Cicindela lepida* Dejean (Figs. 32 & 54)

Recognition.— (Fig. 32) Adults of this species are the palest tiger beetles in Alberta and have obscure markings and pale legs offering them excellent cryptic protection on pale sand. It is often easier to see the beetle's shadow on the ground than it is to see the beetle.

Notes.— Adults of *Cicindela lepida* may become inactive when ground surface temperatures exceed 48° C during midafternoon. They burrow beneath the lethal temperature zone and resume activity when the temperature drops later in the day. On warm evenings activity will continue through the night, with short pauses at dusk and dawn. When night time temperatures exceed 25° C (rarely in Alberta), adults may disperse. In Nebraska I have collected flying adults in a black light trap many kilometers from the nearest sand dune.

Habitat.— Representatives of *Cicindela lepida* occur on pale yellow to white sand, usually on sand dunes. No vegetation or other protective cover is present. Adults prefer wind-swept dune crests and larvae are found in sheltered bowl areas on sand dunes. Members of this summer species take two years to complete their life cycle (Criddle 1910, Hamilton 1925, Shelford 1908). Adults are present from late June to early August in Alberta.

Localities.— (Fig. 54) Empress (11 km south).

Tiger beetles of the species *Cicindela lepida* occur in the Great Sandhills of Saskatchewan, just east of the Alberta boundary. Specimens should be watched for in the sand dunes and blowouts of the Middle Sand Hills of Alberta.

20. Other species.

In Vaurie's paper (1950, p. 153) *Cicindela togata* La Ferté is reported to occur in Alberta. This report is a typographical error and should read *C. tranquebarica* as per species references later on the page. No additional records or specimens have been located. Wallis (1961) did not include this species as part of the Canadian tiger beetle fauna. The known range of *Cicindela togata* does not extend north of Nebraska (Willis 1967). This species is not expected to be found in Alberta.

Members of *Cicindela togata* inhabit alkali mud flats a type of habitat abundant in the south eastern corner of the province. Adults are pale with reduced pigment areas of the elytra. For details on appearance and habitat see Willis (1967).

Another species not yet recorded but to be watched for is *Cicindela cuprescens* LeConte. This species occurs in Manitoba and along the lower reaches of the Milk River in Montana. Adults are characterized by a peculiarly shaped humeral lunule, which resembles the maculations found on beetles of *C. nevadica knausi*. The strongly embossed maculations distinguish specimens of *C. cuprescens* from those of *C. n. knausi*. In Manitoba, adults of *C. cuprescens* have been collected on the sandy crest of a ravine. Willis (1967) characterized these beetles as inhabitants of fluvial mesic and saline habitats. This species may occur along the Milk River drainage in southern Alberta.

BIOGEOGRAPHIC CONSIDERATIONS

The Albertan tiger beetle fauna is of relatively recent origin. The displacement of biota by the Wisconsian glaciation is well documented (e.g. Wright and Frey 1965, Flint 1971, Matthews, 1979, etc). Movement of biota back into glaciated regions is not as well understood.

Faunal and floral elements survived in well-identified refugia during this glaciation but which elements of the biota survived in which refugia? Workers (e.g. Ross 1970, Martin 1958, Frenzel 1973, etc.) have variously interpreted where these elements went and which factors influenced their distribution.

A poor fossil record for beetles (Morgan *et al.* 1983) necessitates the use of distribution patterns to interpret faunal source regions for Albertan tiger beetles. Modern species/subspecies distribution maps (Freitag 1965, Wallis 1961, Willis 1967) provide data on possible source regions. Source areas for Albertan tiger beetles can, potentially, be any of the following; 1) nunataks: refugia surrounded by glacial ice usually harbouring endemic forms; 2) north of the ice: unglaciated areas of Alaska and the Yukon; and 3) south of the ice: unglaciated continental North America. Region 3 can be subdivided into three major subregions, a) western: the Pacific Northwest, west of the Rocky Mountains, b) central: the Great Plains region, and c) eastern, including the boreal forest.

Tiger beetles are sensitive to low temperature and short growing season as shown by their absence from extreme northern, alpine and subalpine regions. It is therefore unlikely that any species survived on nunataks within glacial areas or in regions close to ice margins during glacial maxima.

A northern source area for Albertan tiger beetles is suggested by present distribution patterns (Fig. 56). One species, *C. oregona*, has several subspecies. Freitag (1965) showed that *C. oregona guttifera* ranges from Alaska and the Yukon through northern British Columbia. From central British Columbia and south, *C. oregona guttifera* hybridizes with *C. oregona oregona* in a zone which extends south along the Rocky Mountains into Utah. From Colorado and south into New Mexico *C. oregona guttifera* hybridizes with *C. oregona navajoensis* Van Dyke and with *C. oregona maricopa* Leng in southwest Utah. "Pure" populations of *C. oregona guttifera* occur in Colorado and New Mexico in the south and in northern British Columbia, Yukon and Alaska. These widely separated population loci and extensive zones of hybridization suggest that the ancestors of *C. oregona guttifera* were isolated in the unglaciated regions of Alaska and the Yukon in the north and in the mountainous areas of New Mexico and Colorado east of the Great Divide during the last glacial period. Populations of these beetles dispersed north and south following deglaciation whereby contact was renewed with other subspecies/sibling species. The hybrid zones reported by Freitag (1965) are these areas of contact. Thus it appears that at least one tiger beetle species may have dispersed into Alberta from a northern refugium.

The remaining tiger beetle species probably originated from source areas south of the Wisconsinan ice margin. One subspecies, *C. limbata hyperborea* may be tentatively attributed to a southeastern origin. These tiger beetles are restricted to the boreal forest in northern Alberta and Saskatchewan (Fig. 56). A problem with attributing an eastern origin to the subspecies is that there are no extant populations known from the east. Rates of subspeciation have been proposed for montane carabids (Kavanaugh 1979) but it is not known how quickly tiger beetles can subspeciate. In most tiger beetle species there is considerable individual variation. It is possible that such rates are rapid and that *C. l. hyperborea* evolved to subspecies status while isolated on the jack pine sand plains of northern Alberta and Saskatchewan in the past 7000 years. Another explanation is that ancestral populations survived on "boreal" sand hills south of glacial ice and are now absent from these areas. Additional research is required to solve this problem.

A southwestern source region for *Cicindela terricola imperfecta* and *C. oregona oregona*(Fig. 56) is readily supported by populations found along mountain passes and valleys of western Alberta. Populations of these beetles appear to be in the process of dispersing and colonizing Alberta. Both subspecies occur in British Columbia and the U.S.A., west of the Great Divide.

The remaining Albertan tiger beetles probably originated on the central Great Plains. Populations of these species in Alberta are simply northern extensions of these ranges (Fig. 55). Habitat and climate appear to limit dispersal. Ranges of summer species do not extend north of the prairie grasslands, whereas some spring-fall species have ranges extending north into the Northwest Territories along streams and river banks (*C. splendida limbalis*, *C. tranquebarica*, *C. duodecimguttata*, *C. repanda*). A number of 'southern grassland' tiger beetle species (*C. decemnotata*, *C. lengi versuta*, and *C. terricola cinctipennis*) occur in the prairie regions of the Peace River district and two species (*C. decemnotata*, and *C. t. cinctipennis*) in the grasslands of the Yukon. This distribution parallels that of many plant species (Moss 1952).

Following deglaciation the fauna moved around, adjusting to changes in climate. About 7000 years B.P. a prolonged warm period, the hypsithermal occurred. During this time, prairie grasslands probably expanded north in Alberta at the expense of the forested regions. The grasslands of the Peace River district and the southern prairies were continuous, with a resulting exchange of floral and faunal elements. Since the hypsithermal, the climate has cooled and the forests have reclaimed much of these grasslands. This has resulted in the reduction and isolation of remnants of northern grasslands with their relict prairie flora and fauna.

Other tiger beetle species (*C. lepida*, *C. formosa*) may have dispersed north into Alberta during the hypsithermal when dune habitats were in abundance. Riparian species (*C. repanda*, *C. duodecimguttata*, *C. hirticollis*) followed the changing water sheds, losing habitat in times of drought and flood. Species of alkaline mud flats (*C. fulgida*, *C. nevadica*) would lose habitat during pluvial periods and gain it back during periods of drought. The tiger beetle fauna is thus in a constant state of flux. Some species are still colonizing the province, some are represented by relict populations, and others are adapting and flourishing in the wake of man's activities: colonizing and dispersing along roadways, and breeding in construction sites. Agriculture has destroyed some habitats and created others.

ACKNOWLEDGEMENTS

I wish to thank my many friends who assisted in the development of this paper: B.F. and J.L. Carr, C. van Nidek, J.H. Acorn, E.M. Pike, and F.A.H. Sperling for providing collection data and companionship in the field; C.D. Bird the mentor of my first term paper on Alberta tiger beetles; and G.E. Ball for opening his home and the U. of Alberta collection to me in 1975 to begin research on the tiger beetles of Alberta. Special thanks are extended to J.H. Acorn and F.A.H. Sperling for critically reviewing and suggesting improvements to this manuscript.

REFERENCES

Criddle, N. 1907. Habits of some Manitoba tiger beetles (Cicindelidae). The Canadian Entomologist. 39: 105–114.

Criddle, N. 1910. Habits of some Manitoba tiger beetles, No. 2 (Cicindelidae). The Canadian Entomologist. 42: 9–15.

Flint, B. 1971. Glacial and Quaternary geology. J. Wiley and Sons Inc. 892 pp.

Freitag, R. 1965. A revision of the North American species in the *Cicindela maritima* group with a study of hybridization between *Cicindela duodecimguttata* and *oregona*. Quaestiones Entomologicae. 1: 87–170.

Frenzel, B. 1973. Climatic fluctuations of the Ice Ages. The Press of Western Reserve University, Cleveland and London. 306 pp.

Graves, R.C. 1962. Predation on *Cicindela* by a dragonfly. The Canadian Entomologist. 94: 1231.

Hatch, M.H. 1953. The beetles of the Pacfic Northwest. Part 1. Introduction and Adephaga. University of Washington Press, Seattle, Washington. 340 pp.

Hamilton, C.C. 1925. Studies on the morphology, taxonomy and ecology of the larvae of Holarctic tiger-beetles (family Cicindelidae). No. 2530 Proceedings U. S. National Museum. 65. Art. 17, 1–87, pls. 1–12.

Johnson, W. (in prep). Notes on *Cicindela splendida* Hentz - *limbalis* Klug. - *devenerensis* Casey and *ludoviciana* Leng. Cicindela.

Kavanaugh, D.H. 1979. Rates of taxonomically significant differentiation in relation to geographic isolation and habitat: examples from a study of the nearctic *Nebria* fauna. p 35-57. **In** Carabid beetles: their evolution, natural history, and classification. Eds. Erwin, Ball, Whitehead, and Halpern. Dr. W. Junk bv Publishers. The Hague 1979, 635 pp.

Lavingne, R.J. 1972. Cicindelids as prey of robberflies (Diptera: Asilidae). Cicindela 4(1): 1–7.

Martin, P.S. 1958. Pleistocene ecology and biogeography of North America. pp. 375–420. **In** Hubbs, C.L. (Ed.). 1958. Zoogeography. American Association for Advancement of Science, Symposium. Washington, D.C.

Matthews, J.V., jr. 1979. Tertiary and Quaternary environments: historical background for an analysis of the Canadian insect fauna. pp. 31–86. **In** Danks, H.V. (Ed.). 1979. Canada and its insect fauna. Memoirs of the Entomological Society of Canada. No. 108, 573 pp.

Morgan, A.V., A.C. Achworth and J.V. Matthews jr. 1983. Late Wisconsin fossil beetles in North America. **In** Porter, S.S. (Ed.). 1983. Late Quaternary environments of the United Sates, Vol. 1. University of Minnesota Press, Mineapolis. 407 pp.

Moss, E.H. 1952. Grassland of the Peace River region, western Canada. Canadian Journal of Botany. 30:98–124.

Ross, H.E. 1970. The ecological history of the Great Plains, evidence from grassland insects. pp. 225–240. **In** Dort, W. and J.K. Jones (Ed.). 1970. Pleistocene and recent environments of the Central Great Plains. Department of Geology, University of Kansas Special Publication 3, University of Kansas Press. 433 pp.

Shelford, V.E. 1908. Life histories and larval habits of the tiger beetles (Cicindelidae). The Journal of the Linnaean Society, London. 30: 157–184, pls. 23–26.

Swan, L.A. 1975. Tiger Beetle. Insect World Digest. Jan/Feb. 1975: 1-5.

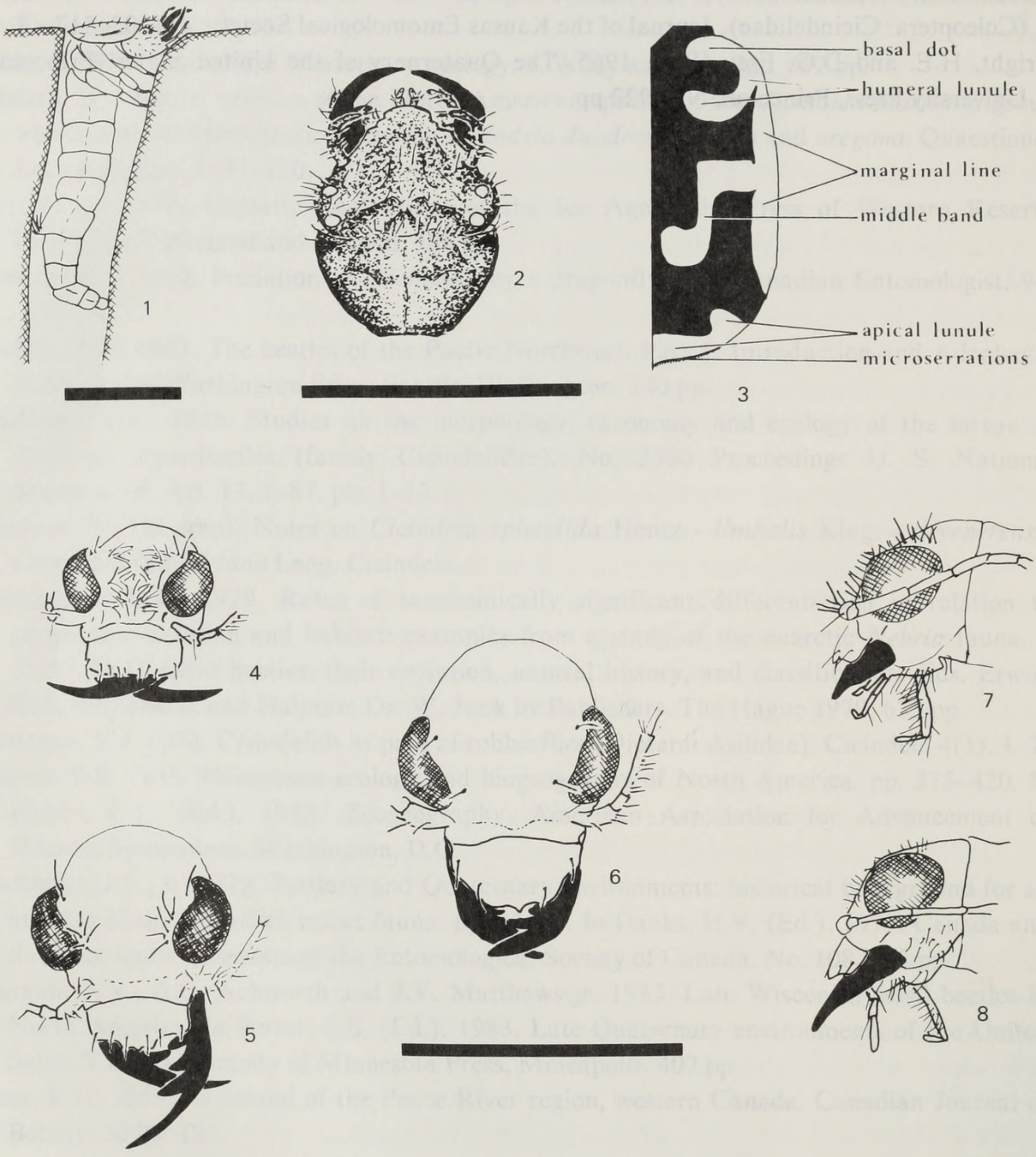
Vaurie, P. 1950. Notes on the habitats of some North American tiger beetles. Journal of the New York Entomological Society. 58: 143–153.

Wallis, J.B. 1961. The Cicindelidae of Canada. University of Toronto Press, Ontario. 74 pp.

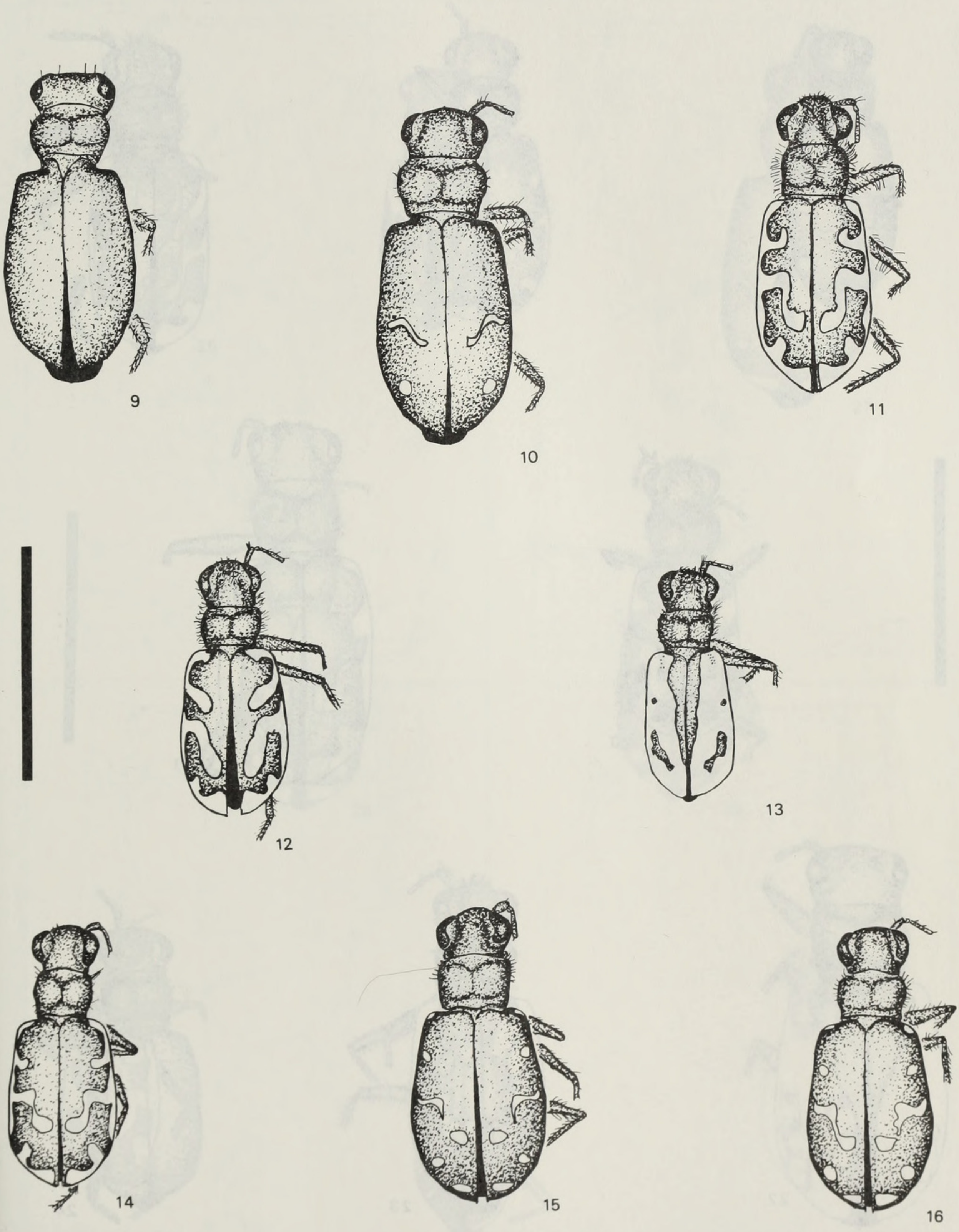
Willis, H.L. 1967. Bionomics and zoogeography of the tiger beetles of saline habitats in the central United States (Coleoptera: Cicindelidae). University of Kansas Science Bulletin. 47(5):143–313.

Willis, H.L. 1968. Artificial key to the species of *Cicindela* of North America north of Mexico (Coleoptera: Cicindelidae). Journal of the Kansas Entomological Society. 41: 303–317.

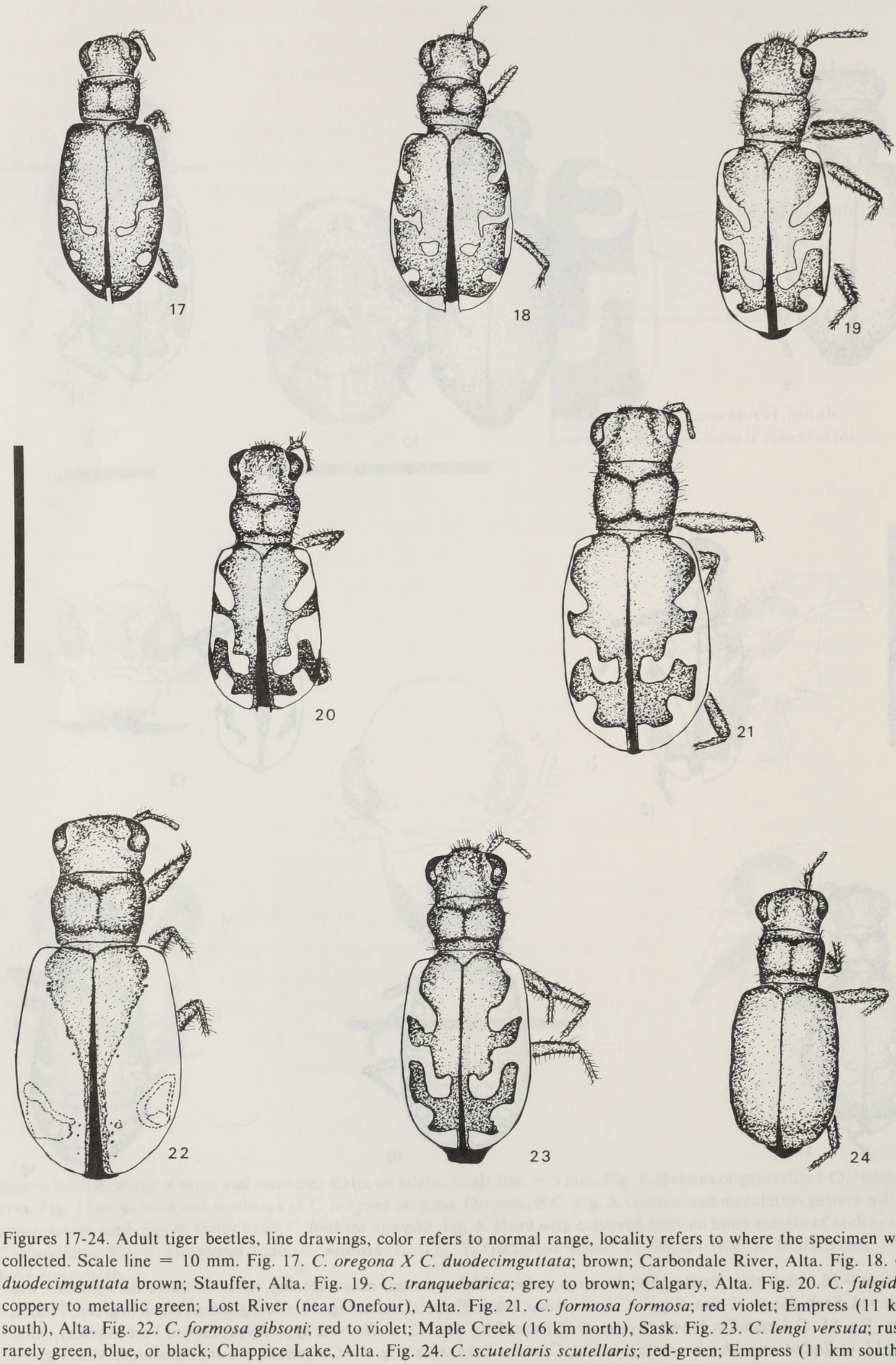
Wright, H.E. and D.G. Frey (Ed.). 1965. The Quaternary of the United States. Princeton University Press, Princeton, N.J. 922 pp.



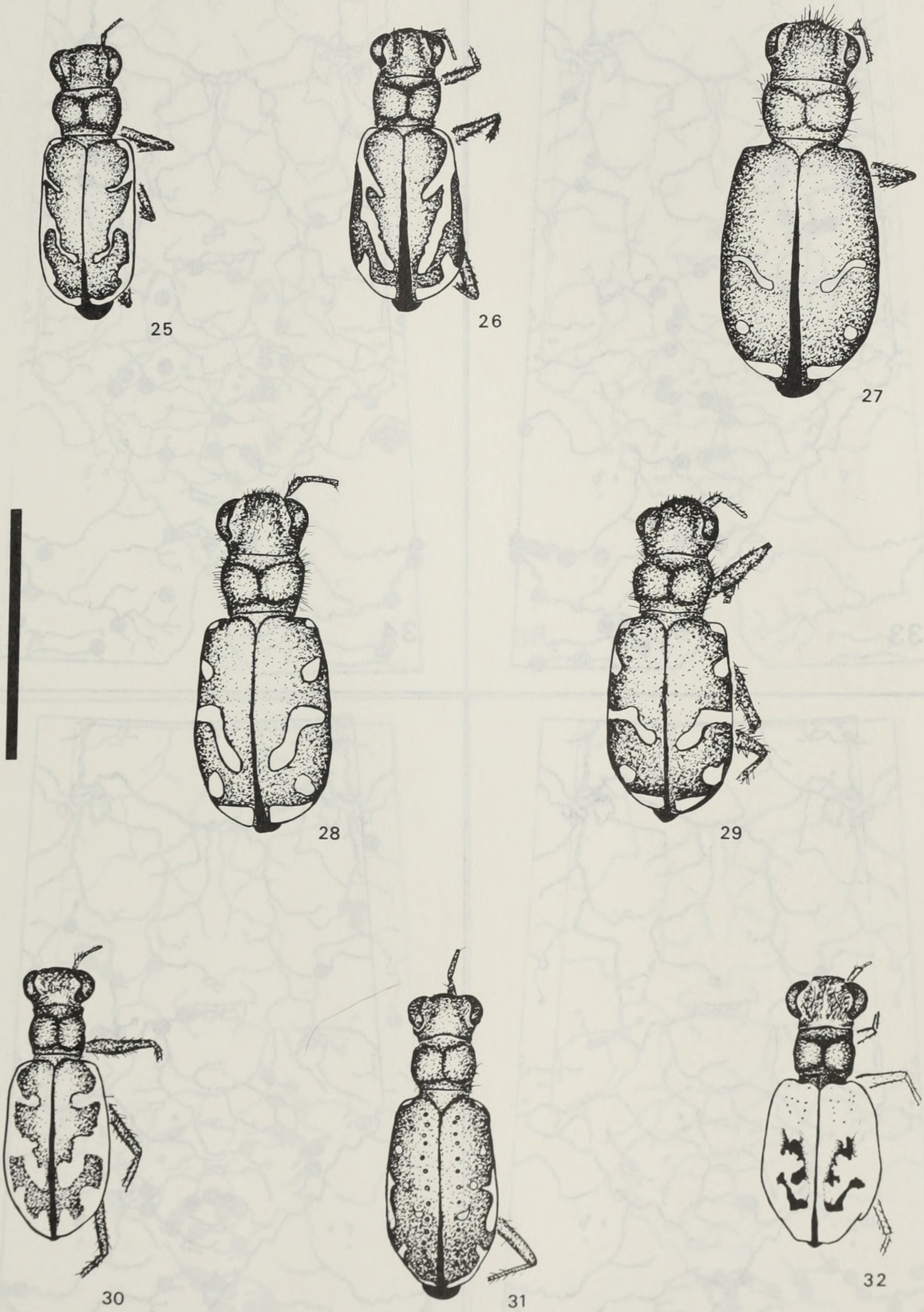
Figures 1-8. Drawings of larva and character states on adults. Scale line = 5 mm. Fig. 1. Habitus of generalized *Cicindela* larva. Fig. 2 Larval head and prothorax of *C. oregona oregona,* Osoyoos, B.C. Fig. 3. Generalized maculation pattern with nomenclature used. Fig. 4. Hairy head; *C. limbata nympha.* Fig. 5. Head with culstered hairs on inner margin of each eye; *C. scutellaris.* Fig. 6. Glaborous head; *C. nebraskana.* Fig. 7. Glaborous genae; *C. fulgida.* Fig. 8. Hairy genae; *C. duodecimguttata.*



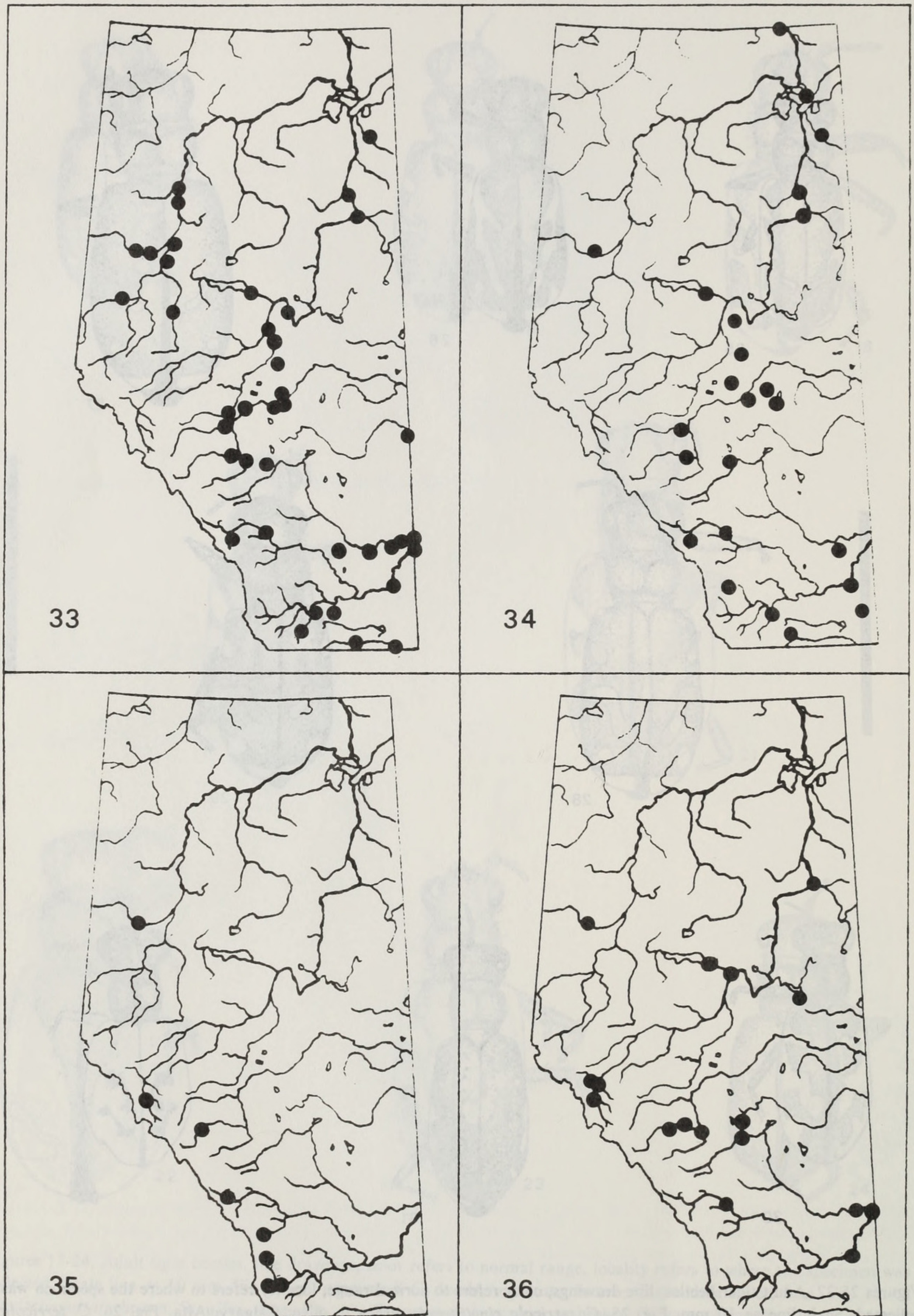
Figures 9-16. Adult tiger beetles, line drawings, color refers to normal range, locality refers to where the specimen was collected. Scale line = 10 mm. Fig. 9. *C. nebraskana*; black; Empress, Alta. Fig. 10. *C. longilabris*; black to green; Fedora, Alta. Fig. 11. *C. hirticollis*; brown to olive; Gull Lake, Alta. Fig. 12. *C. limbata hyperborea*; brown; Fort MacKay, Alta. Fig. 13. *C. limbata nympha*; brown to greenish; Crimson Lake, Alta. Fig. 14. *C. repanda*; brown; Edmonton, Alta. Fig. 15. *C. oregona oregona*; brown, green, blue; Summerland, B.C. Fig. 16. *C. oregona guttifera*; brown; Kootenay Plains, Alta.



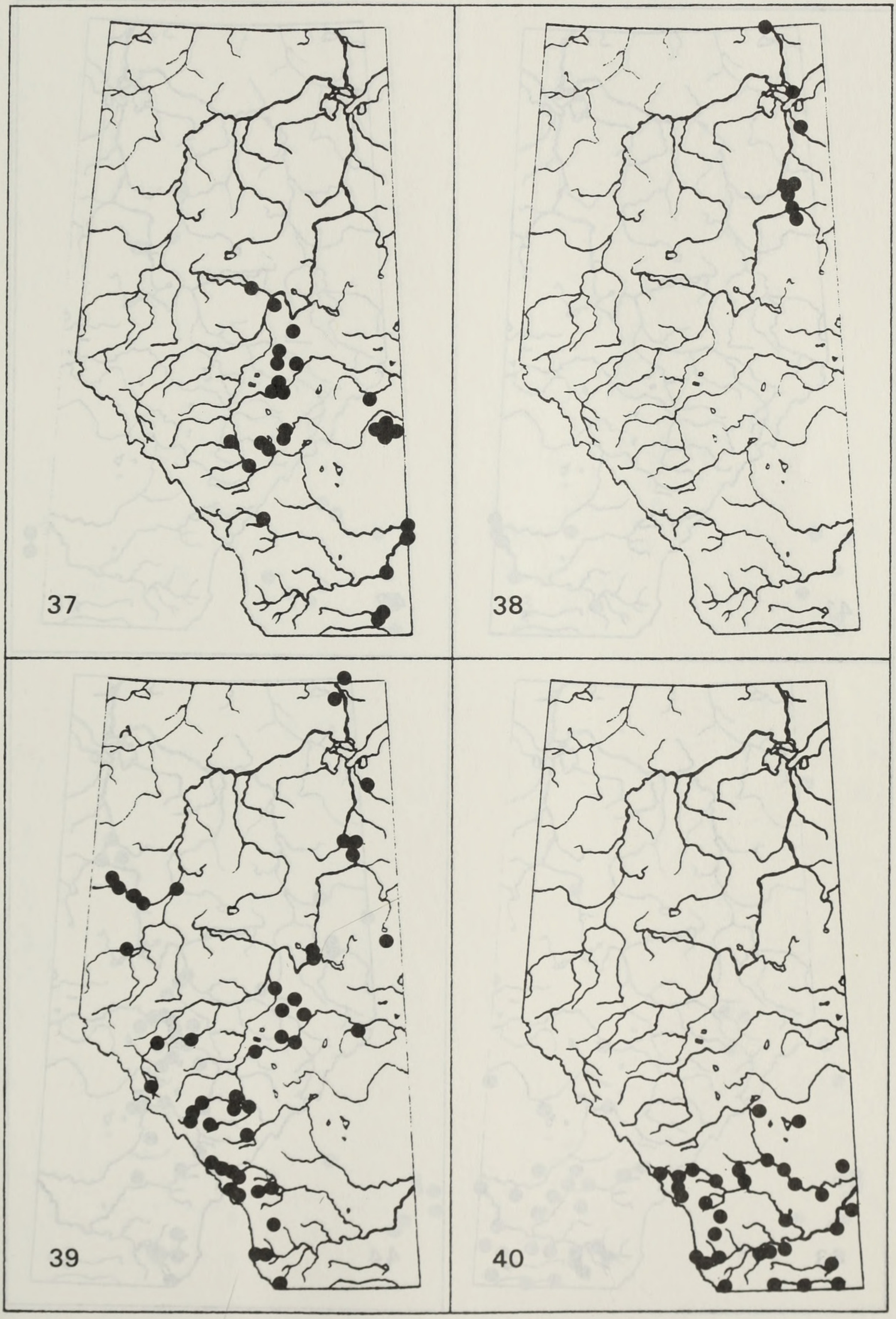
Figures 17-24. Adult tiger beetles, line drawings, color refers to normal range, locality refers to where the specimen was collected. Scale line = 10 mm. Fig. 17. *C. oregona X C. duodecimguttata*; brown; Carbondale River, Alta. Fig. 18. *C. duodecimguttata* brown; Stauffer, Alta. Fig. 19. *C. tranquebarica*; grey to brown; Calgary, Alta. Fig. 20. *C. fulgida*; coppery to metallic green; Lost River (near Onefour), Alta. Fig. 21. *C. formosa formosa*; red violet; Empress (11 km south), Alta. Fig. 22. *C. formosa gibsoni*; red to violet; Maple Creek (16 km north), Sask. Fig. 23. *C. lengi versuta*; rust, rarely green, blue, or black; Chappice Lake, Alta. Fig. 24. *C. scutellaris scutellaris*; red-green; Empress (11 km south), Alta.



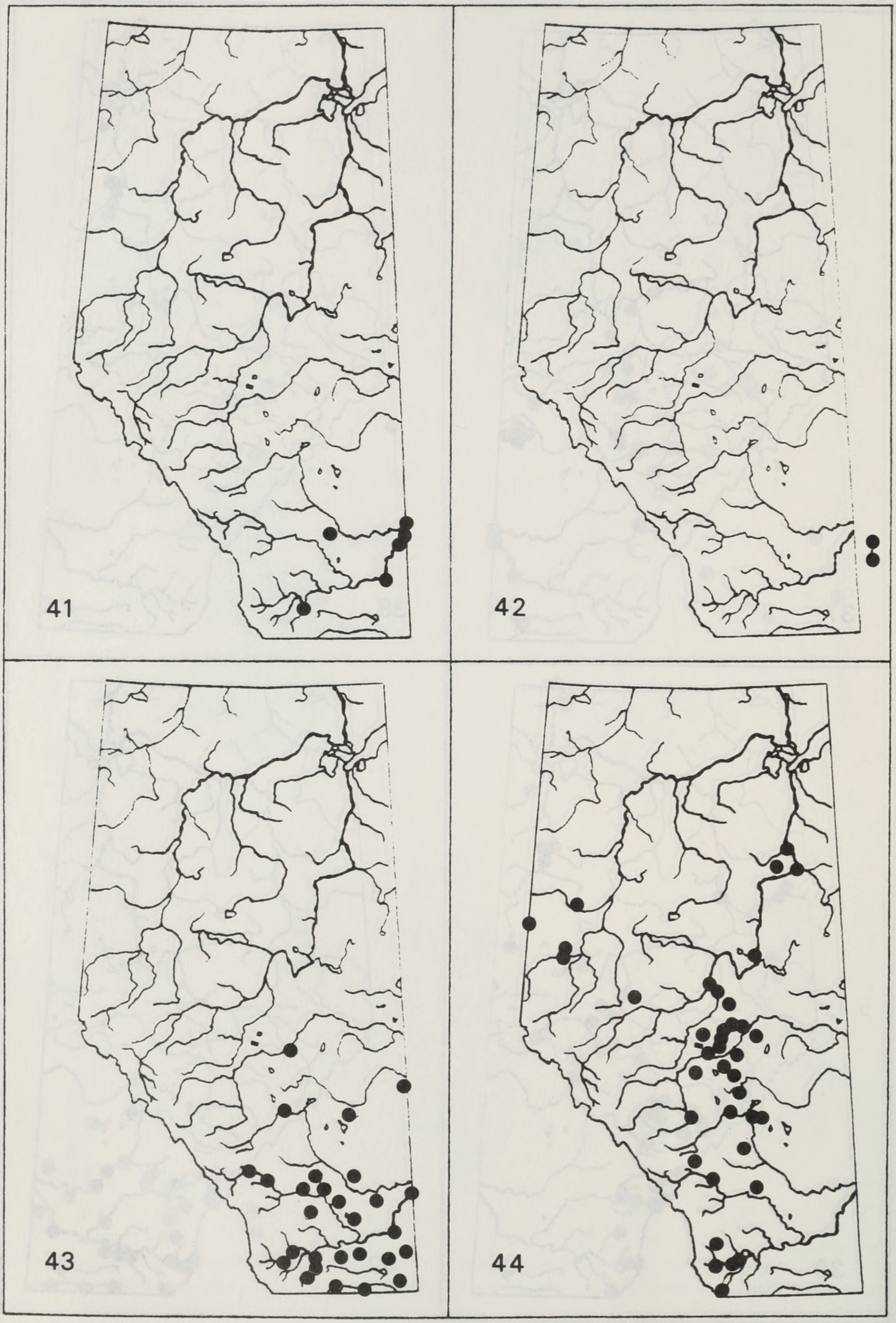
Figures 25-32. Adult tiger beetles, line drawings, color refers to normal range, locality refers to where the specimen was collected. Scale line = 10 mm. Fig. 25. *C. terricola cinctipennis*; green to olive; Calgary, Alta. Fig. 26. *C. terricola imperfecta*; green to olive; Kootenay Plains, Alta. Fig. 27. *C. purpurea*; green or black; Lost River (near Onefour), Alta. Fig. 28. *C. decemnotata*; green; Lethbridge, Alta. Fig. 29. *C. splendida limbalis*; red to green; Crimson Lake, Alta. Fig. 30. *C. nevadica knausi*; copper to brown; Jenner Ferry, Alta. Fig. 31. *C. punctulata*; grey brown; Empress (11 km south), Alta. Fig. 32. *C. lepida*; pale with brown; Empress (11 km south), Alta.



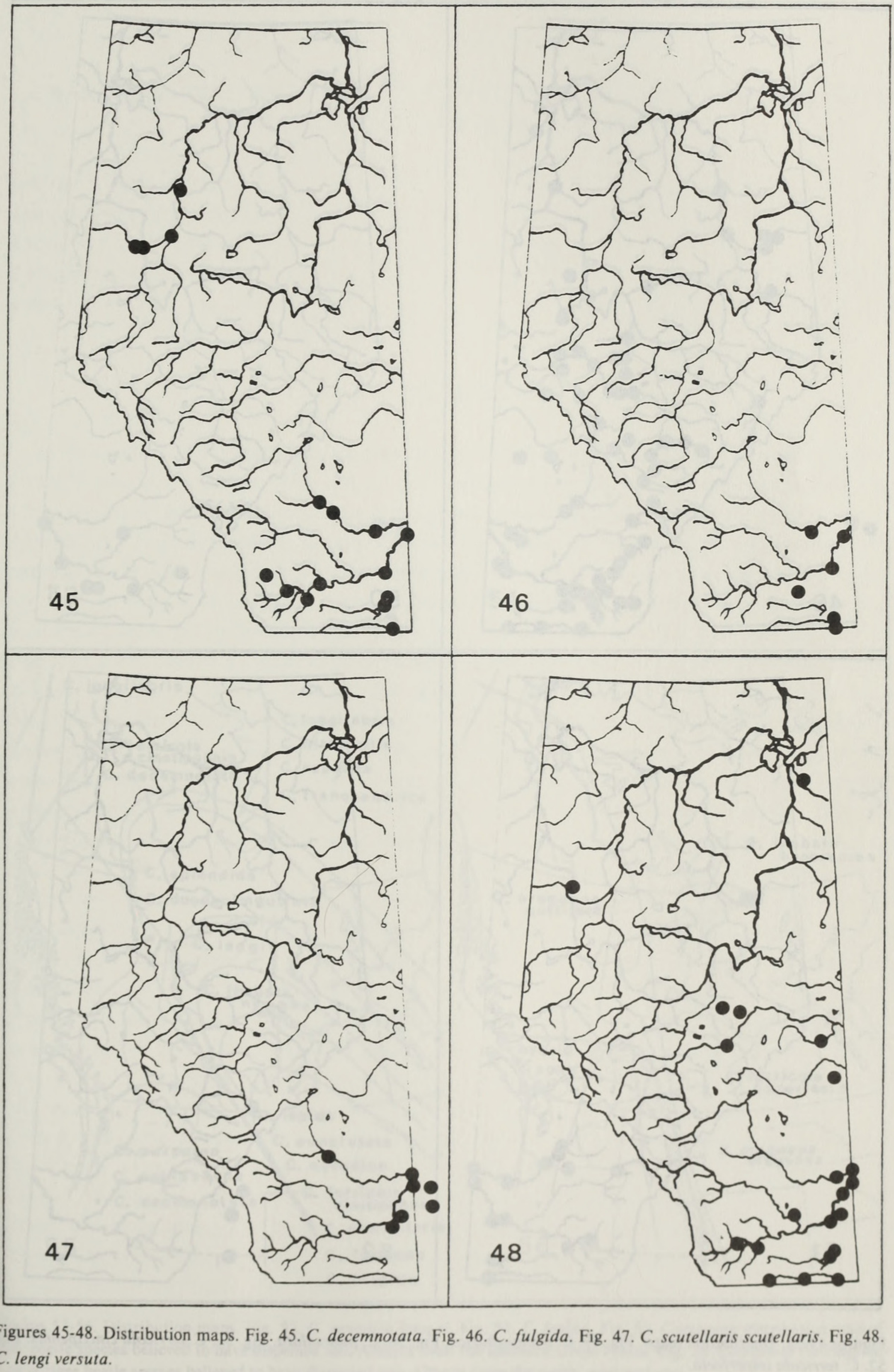
Figures 33-36. Distribution maps. Fig. 33. *C. repanda*. Fig. 34. *C. duodecimguttata*. Fig. 35. *C. oregona*. Fig. 36. *C. hirticollis*.



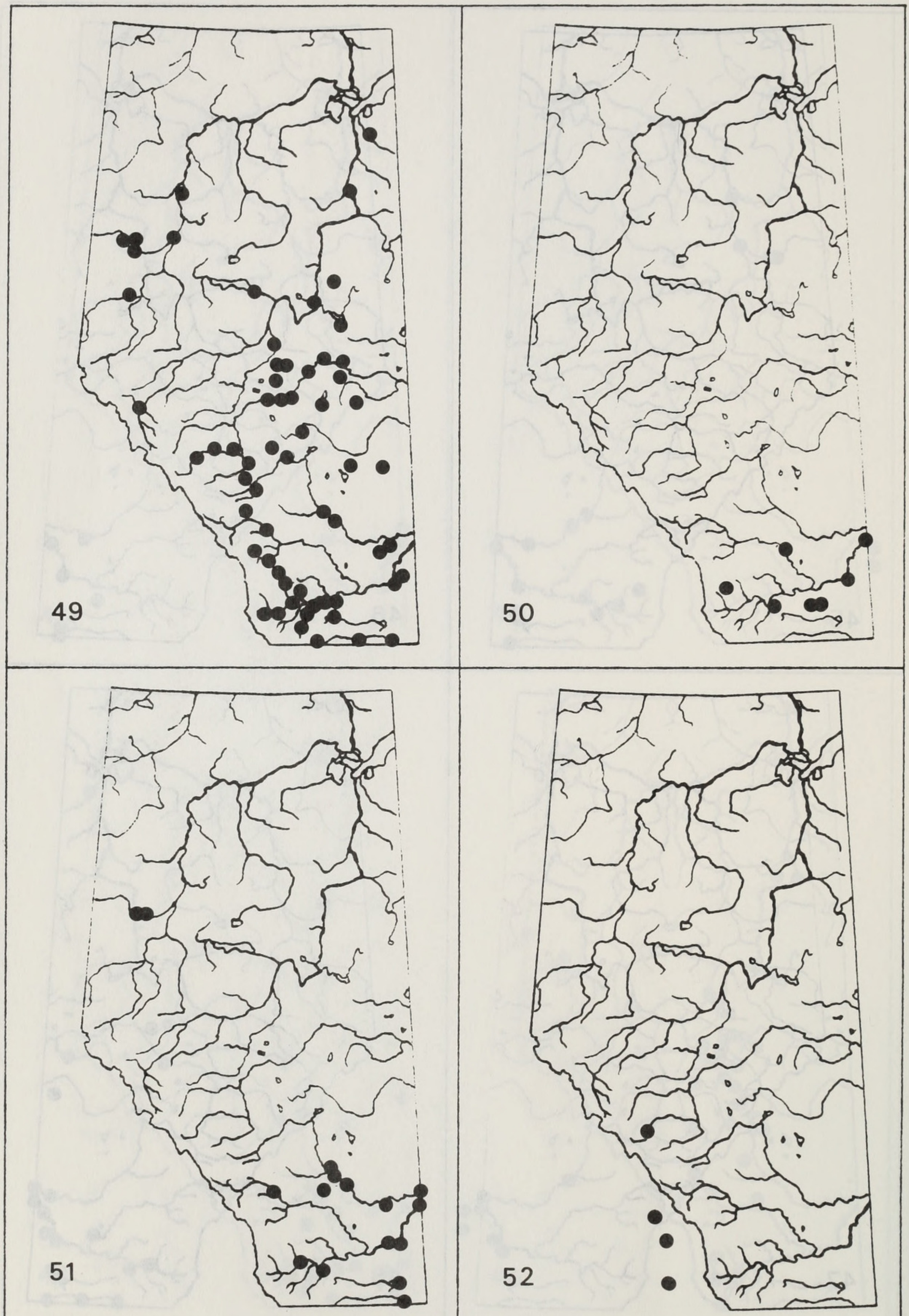
Figures 37-40. Distribution maps. Fig. 37. *C. limbata nympha*. Fig. 38. *C. limbata hyperborea*. Fig. 39. *C. longilabris*. Fig. 40. *C. nebraskana*.



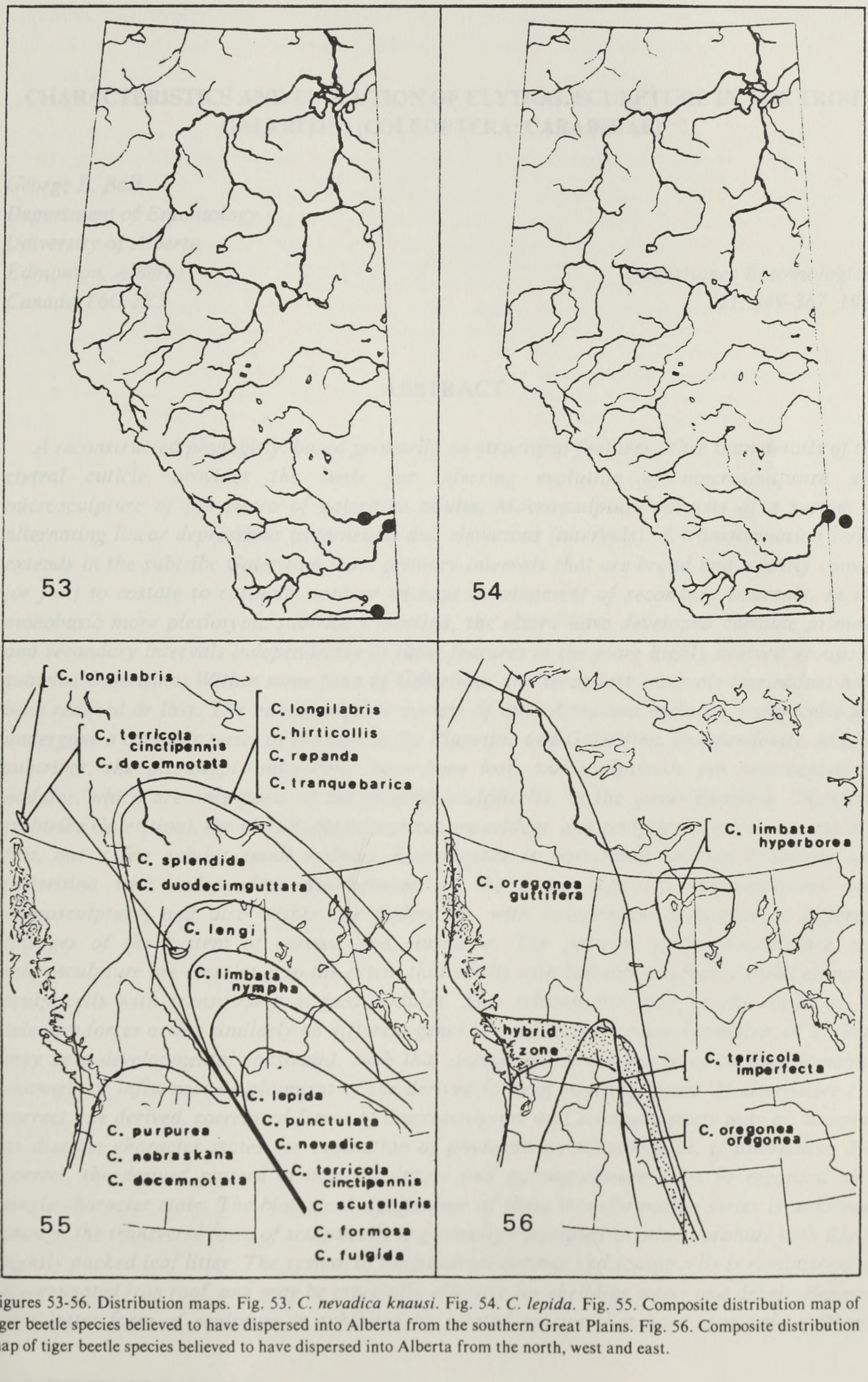
Figures 41-44. Distribution maps. Fig. 41. *C. formosa formosa*. Fig. 42. *C. formosa gibsoni*. Fig. 43. *C. purpurea*. Fig. 44. *C. splendida limbalis*.



Figures 45-48. Distribution maps. Fig. 45. *C. decemnotata*. Fig. 46. *C. fulgida*. Fig. 47. *C. scutellaris scutellaris*. Fig. 48. *C. lengi versuta*.



Figures 49-52. Distribution maps. Fig. 49. *C. tranquebarica*. Fig. 50. *C. punctulata*. Fig. 51. *C. terricola cinctipennis*. Fig. 52. *C. terricola imperfecta*.



Figures 53-56. Distribution maps. Fig. 53. *C. nevadica knausi*. Fig. 54. *C. lepida*. Fig. 55. Composite distribution map of tiger beetle species believed to have dispersed into Alberta from the southern Great Plains. Fig. 56. Composite distribution map of tiger beetle species believed to have dispersed into Alberta from the north, west and east.